

IMPERIAL NATIONAL WILDLIFE REFUGE FISH POND ENHANCEMENT PROGRAM

GEOTECHNICAL AND GEOHYDROLOGICAL FINDINGS DECEMBER 2005—JANUARY 2006



Imperial National Wildlife Refuge Fish Pond Enhancement Program

Geotechnical and Geohydrological Findings

Scope of Project:

Geotechnical investigations were performed in order to ascertain the presence of permeable sediments near the existing fish ponds in anticipation of drilling several high capacity production wells. Additionally, sediment samples were collected in the upper zones to determine the percentage of fines.

Location:

The project site is located in the west ½ of section 13 and east ½ of section 14, T. 5 S., R. 22 W. The area can be found on the Imperial Reservoir 7.5 minute quadrangle. The site is within the Imperial National Wildlife Refuge (INWR) and bounded on the west by the Colorado River and to the east by the Martinez Lake Inlet Channel. The surface is composed of silty, fine sands of recent Colorado River floodplain deposits (see Figure 1).

Acknowledgements:

Access and coordination was facilitated by personnel and volunteers of INWR. Ken Edwards, Refuge Manager, was instrumental in providing guidance on the refuge and assigning personnel to assist in any logistics. We appreciate the help by Greg Birkenfeld, Assistant Refuge Manager, and John Fairbanks, Refuge Volunteer, in help with the pump test.

Bureau of Reclamation personnel directly involved in drilling and well construction included Charles Jones, Jim Wambeke, Chris Edington, Lonnie Lopez, Ron Torres, and Mike Fairchild. Jim Tate and Florencio Navarrete provided mechanical assistance in the field. John Fitzsimmons performed the sample gradations. Tom Fox assisted with sample collection and logging on three of the holes and finished the well identification stamping and photo documentation. Carroll Brown, Geology Team Leader, assisted with location and logging of the final two wells. Rick Hick of the Surveying Branch performed the final survey of each well site. Front cover photography by Gabriella Lopez.

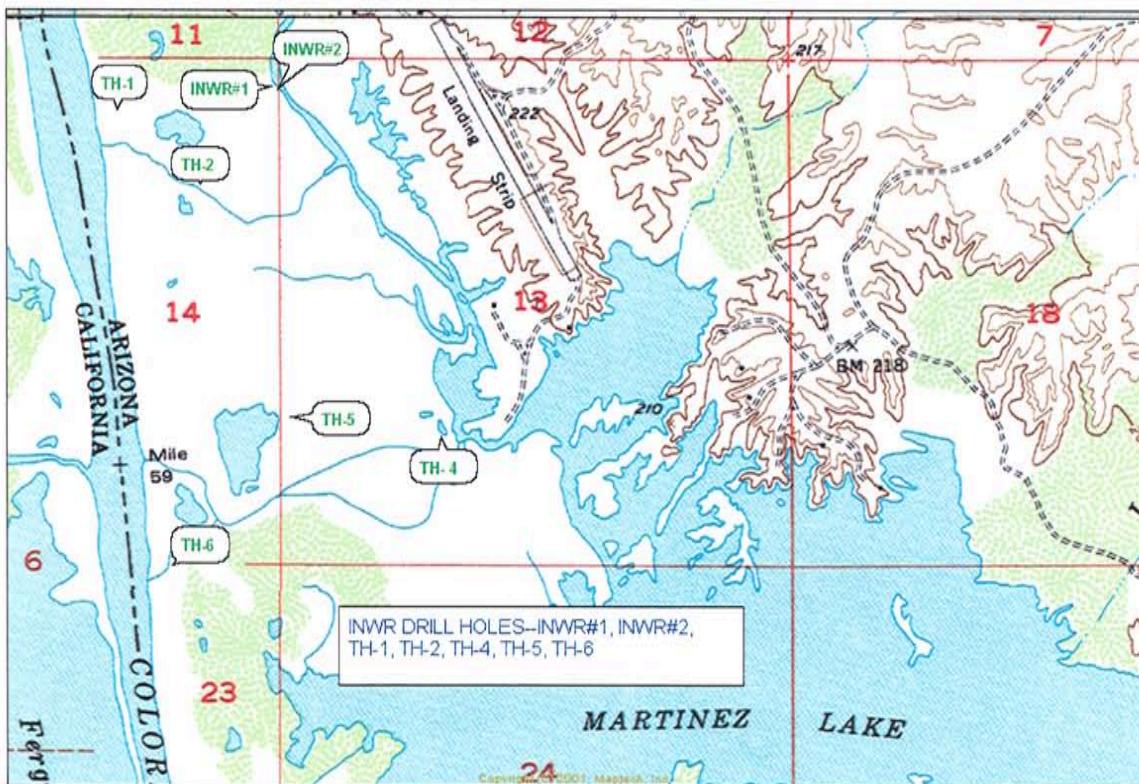


FIGURE 1

Drilling and Geological Logs:

Six drill sites were permitted and drilling began December 19, 2005 and work was completed January 24, 2006. Several sites were moved from their original positions and only five of the six sites were drilled. It was decided the sixth hole was not critical for additional geological data. The drill holes were designated as TH-1 ... 6, with TH implying Test Hole. The following Table 1 summarizes the test holes and detailed geologic, geophysical and completion logs can be found in Appendix I.

TABLE 1

Test Hole	Drill Dates	Drill Depth (ft)	ADWR#
INWR TH-1	12/19/05 – 12/28/05	109	55-209305
INWR TH-6	12/28/05 – 1/5/06	124	55-209310
INWR TH-4	1/9/06 – 1/17/06	99	55-209308
INWR TH-5	1/17/06 – 1/18/06	40.5	55-209309
INWR TH-2	1/18/06 – 1/24/06	40.5	55-209306
INWR TH-3	Not Drilled	----	55-209307

Drilling was accomplished using a CME 85 drill rig. A combination of hollow-stem augering, split-spoon sampling, and direct mud-rotary was employed to gather geologic data and complete the wells. Eight-inch diameter augers were used and mud rotary

drilling used a four-inch tri-cone rock bit. The split-spoon sampler was 1 ½" X 2 foot and samples were collected using the hydraulic drive to push ahead of the auger bit.

Geologic logs of the existing two production wells (INWR #1, drilled in May 1999 and INWR #2, drilled in May 2002) were constructed to conform to the format and interpretations of the exploratory holes. These logs are included in Appendix I.

Subsurface Geology

Detailed geologic logs with water table depths are in Appendix I. A generalized cross section, Figure 2, shows a subsurface geologic profile viewed towards the west (towards the Colorado River). The subsurface geology consists of 60 to 100 feet of unconsolidated Colorado River sediments of which the top 30 to 40 feet is mostly fine-grained silty sand underlain by about 30 to 60 feet of permeable sand and gravel. The sediments are saturated except for the upper 5 feet or so. Minor thin clay layers occur within the silty sand. Underlying the Colorado River sediments is an undetermined thickness of variously consolidated silty, clayey, gravelly sand collectively referred to as fanglomerate. Exact starting depth of the fanglomerate was uncertain during drilling and the depths shown in the cross section (Figure 2) are approximate. The fanglomerate is composed of varyingly consolidated alluvial fan deposits of local origin. The fanglomerate has comparatively low permeability. The 30 to 60 feet thick sand and gravel Colorado River sediments appear to have high water-yielding properties. The underlying fanglomerate is thought to be capable of yielding water but to a significantly lesser degree than the overlying sediments.

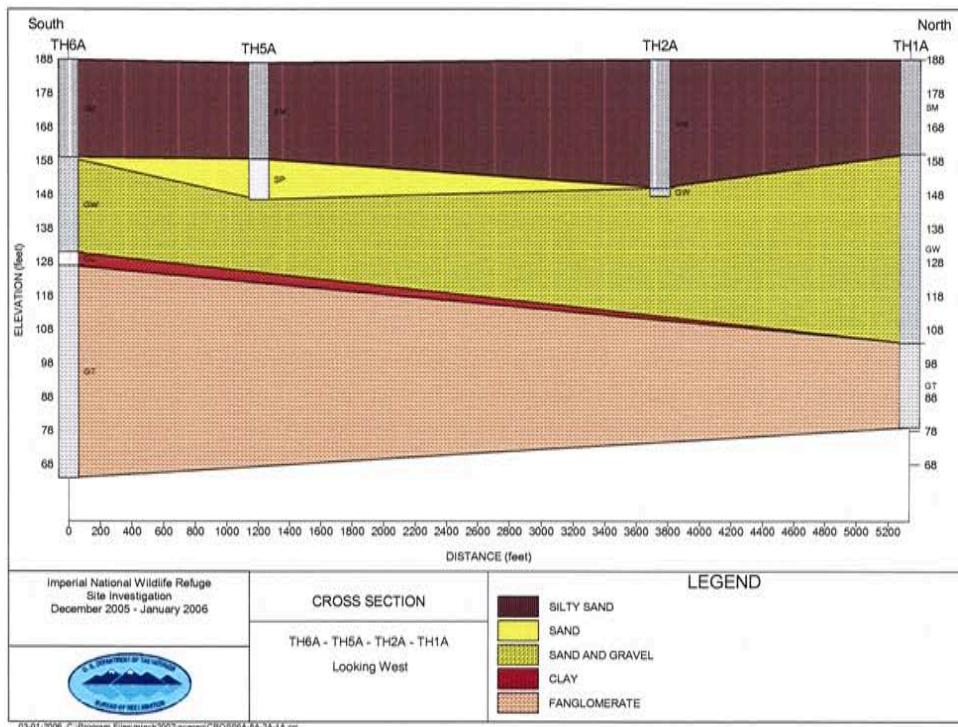


FIGURE 2

Subsurface Sediment Gradations

During drilling push samples were taken at various intervals generally within the first 40 feet of hole. The following Table 2 summarizes the results. The graphical gradation sheets can be found in Appendix II.

TABLE 2

<u>Hole No.</u>	<u>Interval (ft)</u>	<u>Soil Classification</u>	<u>Remarks</u>
TH-1	2.0 – 4.0	SM; Silty sand	
	9.0 – 10.5	SM; Silty sand	
	10.5 – 11.0	SM; Silty sand	
	14.0 – 16.0	ML; Sandy silt	
	19.0 – 19.8	CL; Lean clay	
	19.8 – 20.2	ML; Silt	
	20.2 – 20.3	ML; Sandy silt	
	28.0 – 29.5	SP-SM; Poorly graded sand with silt	
	29.5 – 30.0	SM; Silty sand	
	38.0 – 40.0	SP-SM; Poorly graded sand with silt and gravel	
TH-2	-----	SP; Poorly graded sand	During well development
	8.0 – 10.5	SP-SM; Poorly graded sand with silt	
	18.0 – 20.5	CL; Lean clay	
	28.0 – 30.5	SM; Silty sand	
TH-4	38.0 – 40.5	SP; Poorly graded sand	
	0.0 – 3.0	SM; Silty sand	
	3.0 – 5.0	SM; Silty sand	
	9.6 – 10.5	SP-SM; Poorly graded sand with silt and gravel	
	13.0 – 13.8	SP; Poorly graded sand	
	13.8 – 15.0	SP; Poorly graded sand with gravel	
TH-5	18.0 – 19.1	SW; Well-graded sand with gravel	
	8.0	SM; Silty sand	From auger flight
	18.5 – 20.5	CL; Lean clay	
	28.0 – 28.5	CH; Fat clay	
	28.5 – 30.5	SP-SM; Poorly graded sand with silt	
TH-6	38.5 – 40.5	SP-SM; Poorly graded sand with silt	
	4.0 – 4.2	SM; Silty sand	
	9.0 – 11.0	SM; Silty sand	
	14.0 – 16.0	ML; Silt with sand	
	19.0 – 21.0	SM; Silty sand	

Pump Tests and Aquifer Parameters

A pumping test was done on the water supply well drilled in 2002 and referred to as INWR Well #2. This well was drilled to a depth of 155 feet and screened with 90 feet of 16-inch diameter wirewrap type 304 stainless steel with .02 inch slot width. The screened interval was 46 to 136 feet depth. The four hour test was done on December 29, 2005. The well was pumped at a maximum rate of 1600 gpm. Static water level was 7.04 feet (elevation 183.33 feet above mean sea level). Pumping level at 1600 gpm was 92.53 feet and slowly dropping at the end of the test. Maximum drawdown was 85.49 feet with a specific capacity of 18 gpm per foot of drawdown. Water temperature was 21.6°C (71°F).

A 1 liter water sample was taken for chemical analysis (see Appendix III). Aquifer parameters were estimated from recovery of the pumped well at the end of the test and also recovery of INWR Well #1 (not pumped), 43.5 feet north of INWR Well #2. INWR #1 was drilled in 1999, completed with 14" diameter .03" slot wire-wrap stainless steel screen from 71 to 151 feet depth, and pumped at a maximum rate of about 1400 gpm in 1991. Transmissivity calculated from the recovery of INWR #2 was about 480,000 gpd/foot. Specific yield of the sandy soils above the fanglomerate appears to be about 10% based upon the recovery of INWR Well #1 following the step drawdown test of INWR #2.

This pumping test is believed to be representative of aquifer parameters for the INWR site based upon well logs of INWR #1, INWR #2, and well logs of recently drilled test holes TH-1, TH-2, TH-4, TH-5, and TH-6 (see Appendix IV).

Groundwater/Surface water relations

There is good hydraulic connection between the different layers of the sedimentary soils of the INWR site. Evidence for this is seen by the high transmissivity calculated from the pumping test of INWR #2 and the drawdown of 0.36 feet (static 6.07 feet to 6.43 feet) observed at the new USBR well TH-1-- 1,671 feet away from INWR #2 after 4 hours of pumping. It seems appropriate to evaluate the ground-water reservoir at the site as a water table aquifer with good hydraulic connection between layers of the geologic subsurface, the local ponds, and the Colorado River. Recharge from the ponds and the river to the aquifer should be rapid when wells are pumped with only minor drawdown between wells. Pumped wells a few hundred feet apart should have minimal interference with one another.

Surface and Groundwater Chemistries:

During the course of this study nine water samples were collected for complete analyses. Two of the samples were surface water grab samples. One surface water sample was from the lift pump station at Martinez Lake Inlet. This water, diverted from the Colorado River, is used to flood irrigate fields for water fowl. The other surface water sample was from the Colorado River near TH-6 at the southern end of the existing fish ponds.

The two existing supply wells were sampled during a pump test and each of the test holes were sampled near the end of the pump test or development phase. The complete analyses can be found in Appendix III.

The Colorado River and Martinez Lake Inlet water samples show TDS (Total Dissolved Solids) values (by evaporation) of 808 and 780 mg/L respectively. Several of the test holes exhibit TDS values slightly better than the surface water samples. TH-4 was the only test hole to show anomalously elevated TDS values. TH-4 is located where frequent irrigation of fields occurs and the higher TDS may reflect evapotranspiration effects.

Table 3 is a summary of several parameters from the sampling effort.

TABLE 3

<u>Site</u>	<u>TDS (mg/L)</u>	<u>EC (μsiemens/cm)</u>	<u>Temp. (°C)</u>	<u>Date Coll.</u>
Colorado River	808	1340	10.6	1/5/2006
Martinez Lake Inlet	780	1280	13.1	12/29/2005
INWR #1	832	1210	21.6	12/22/2005
INWR #2	748	1170	21.6	12/29/2005
INWR TH-1	624	1010*	22.2	12/27/2005
INWR TH-2	796	1270	22.8	1/24/2006
INWR TH-4	1350	2120	22.5	1/17/2006
INWR TH-5	788	1270	22.2	1/18/2006
INWR TH-6	672	1130	21.6	1/5/2006

*estimated

Recommendations:

The estimated additional ground-water requirement to operate the enhanced fish ponds is about 3000 gpm. The pump test suggests that the aquifer performance could provide between 700 to 1000 gpm per production well. This is dependent upon site specific aquifer properties, screen length, screen slot size, and gravel pack. We recommend a phased production well installation schedule. This would require, at a minimum, three production wells (and perhaps four) that could be located in the north portion of the study area. The distance between production wells could be as little as 200 feet without significant interference.

Fred Croxen – Geologist Earl Burnett – Geologist

Appendices:

- I. Drill Hole and Completion Logs
- II. Gradations
- III. Water Analyses
 - a. Colorado River at INWR TH-6
 - b. Martinez Lake Inlet
 - c. INWR #1
 - d. INWR #2
 - e. INWR TH-1
 - f. INWR TH-2
 - g. INWR TH-4
 - h. INWR TH-5
 - i. INWR TH-6
- IV. Pump Test Data
- V. Geophysical Logs
- VI. Fence Diagram

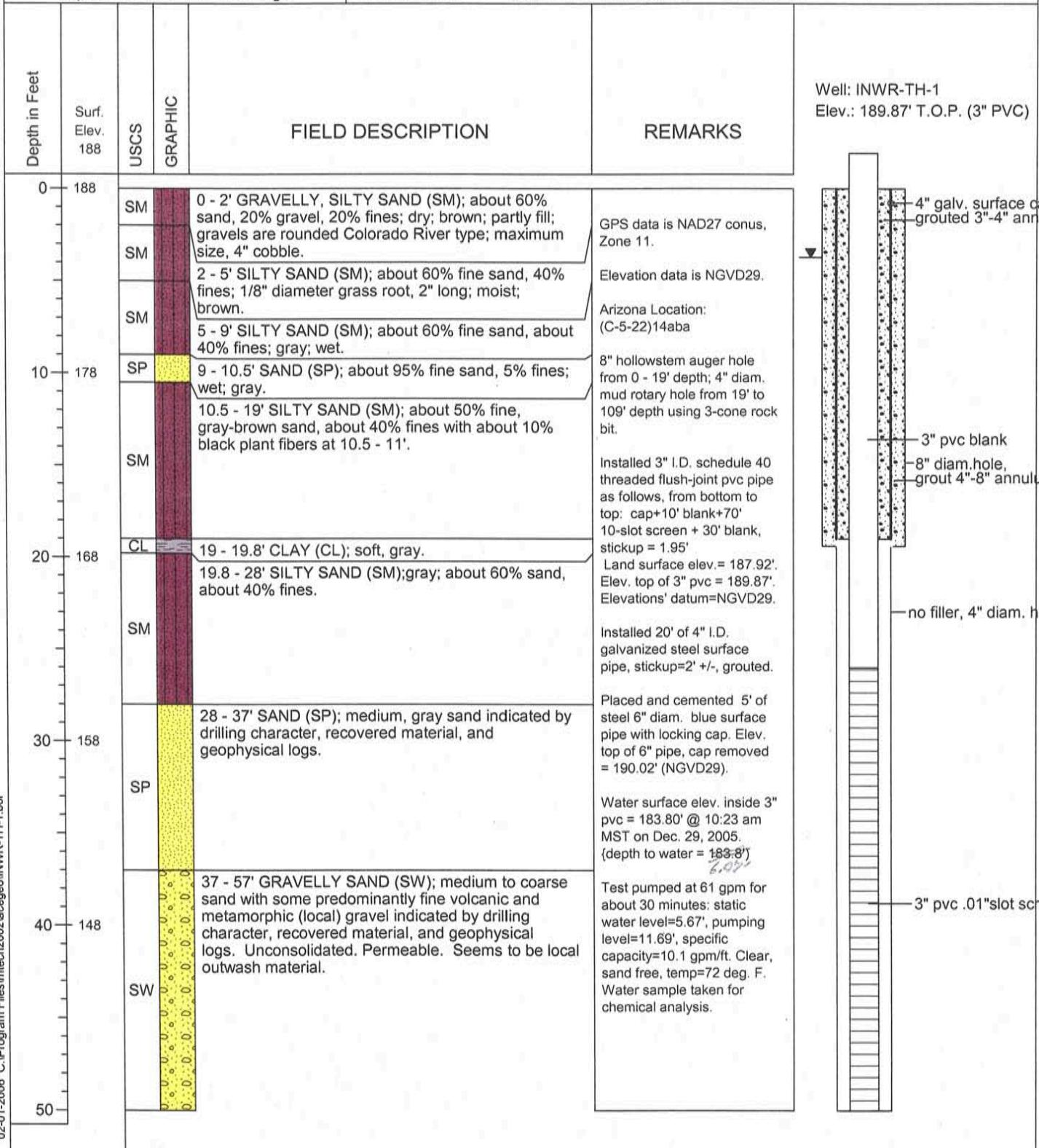
APPENDIX I
DRILL HOLE and COMPLETION LOGS



Imperial National Wildlife Refuge TH-1 ADWR 55-209305

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Bureau of Reclamation Yuma Projects Office Yuma, Arizona	Date Started : 12-19-2005 Date Completed : 12-27-2005 Hole Diameter : 8" 0-38'; 4" 38' - 109' Drilling Method : 8" Hollowstem; 4" mudrotary Logging Method : Action; samples; geophysical	Driller : USBR, Yuma Area Office Northing Coord. : 3653581.8 m (NAD 27, Easting Coord. : 733963.8 m Zone 11) Logged by: FCroxen; EBurnett Approved by:
Test Holes for Water Supply Wells for Fish Ponds Imperial National Wildlife Refuge		

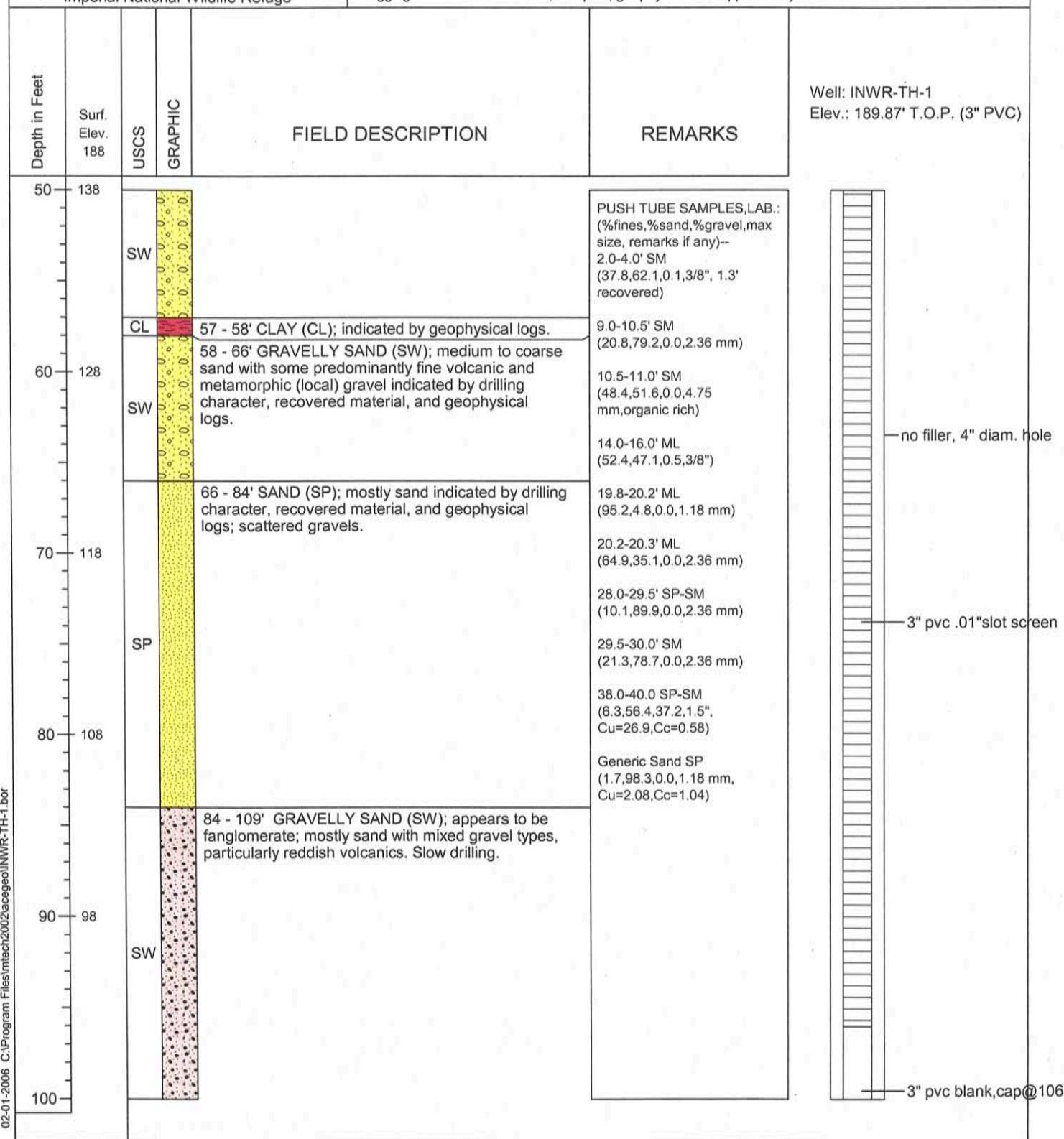




Imperial National Wildlife Refuge TH-1 ADWR 55-209305

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Bureau of Reclamation Yuma Projects Office Yuma, Arizona	Date Started : 12-19-2005 Date Completed : 12-27-2005 Hole Diameter : 8" 0-38'; 4" 38 - 109' Drilling Method : 8" Hollowstem; 4" mudrotary Logging Method : Action; samples; geophysical	Driller : USBR, Yuma Area Office Northing Coord. : 3653581.8 m (NAD 27, Easting Coord. : 733963.8 m Zone 11) Logged by: FCroxen; EBurnett Approved by:
Test Holes for Water Supply Wells for Fish Ponds Imperial National Wildlife Refuge		





Imperial National Wildlife Refuge TH-1 ADWR 55-209305

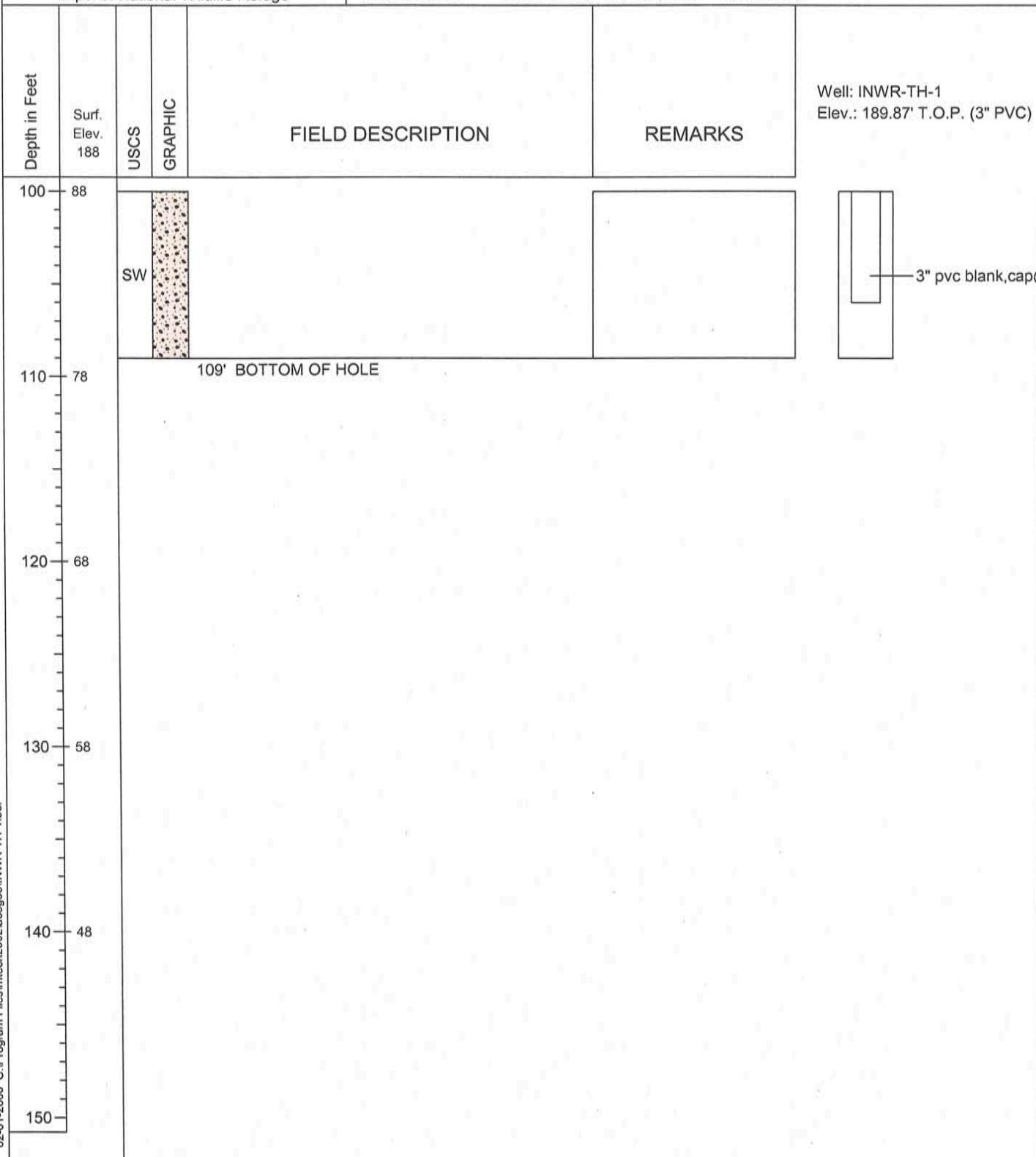
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Bureau of Reclamation
Yuma Projects Office
Yuma, Arizona

Test Holes for Water Supply Wells for Fish Ponds

Imperial National Wildlife Refuge

Date Started : 12-19-2005 Driller : USBR, Yuma Area Office
Date Completed : 12-27-2005 Northing Coord. : 3653581.8 m (NAD 27,
Hole Diameter : 8" 0-38'; 4" 38 - 109' Easting Coord. : 733963.8 m Zone 11)
Drilling Method : 8" Hollowstem; 4" mudrotary Logged by: FCroxen; EBurnett
Logging Method : Action; samples; geophysical Approved by:

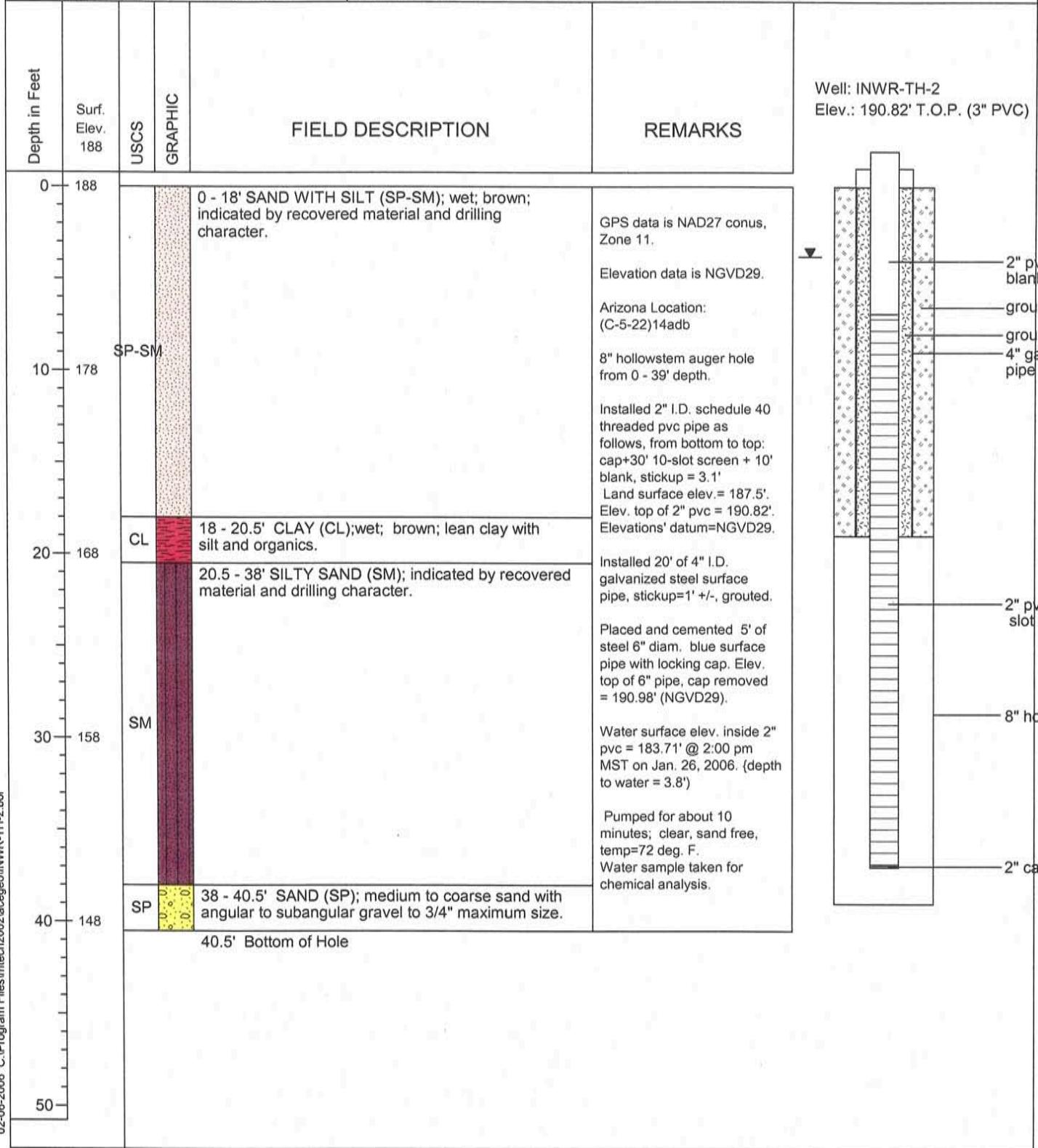




Imperial National Wildlife Refuge TH-2 ADWR 55-209305

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Bureau of Reclamation Yuma Projects Office Yuma, Arizona Test Holes for Water Supply Wells for Fish Ponds	Date Started : 1-18-2006 Date Completed : 1-24-2006 Hole Diameter : 8" 0-40' Drilling Method : 8" Hollowstem Logging Method : Drilling character; samples	Driller : USBR, Yuma Area Office Northing Coord. : 3653338.1 (NAD 27, Easting Coord. : 734238.9 m Zone 11) Logged by: TFox Approved by:
Imperial National Wildlife Refuge		

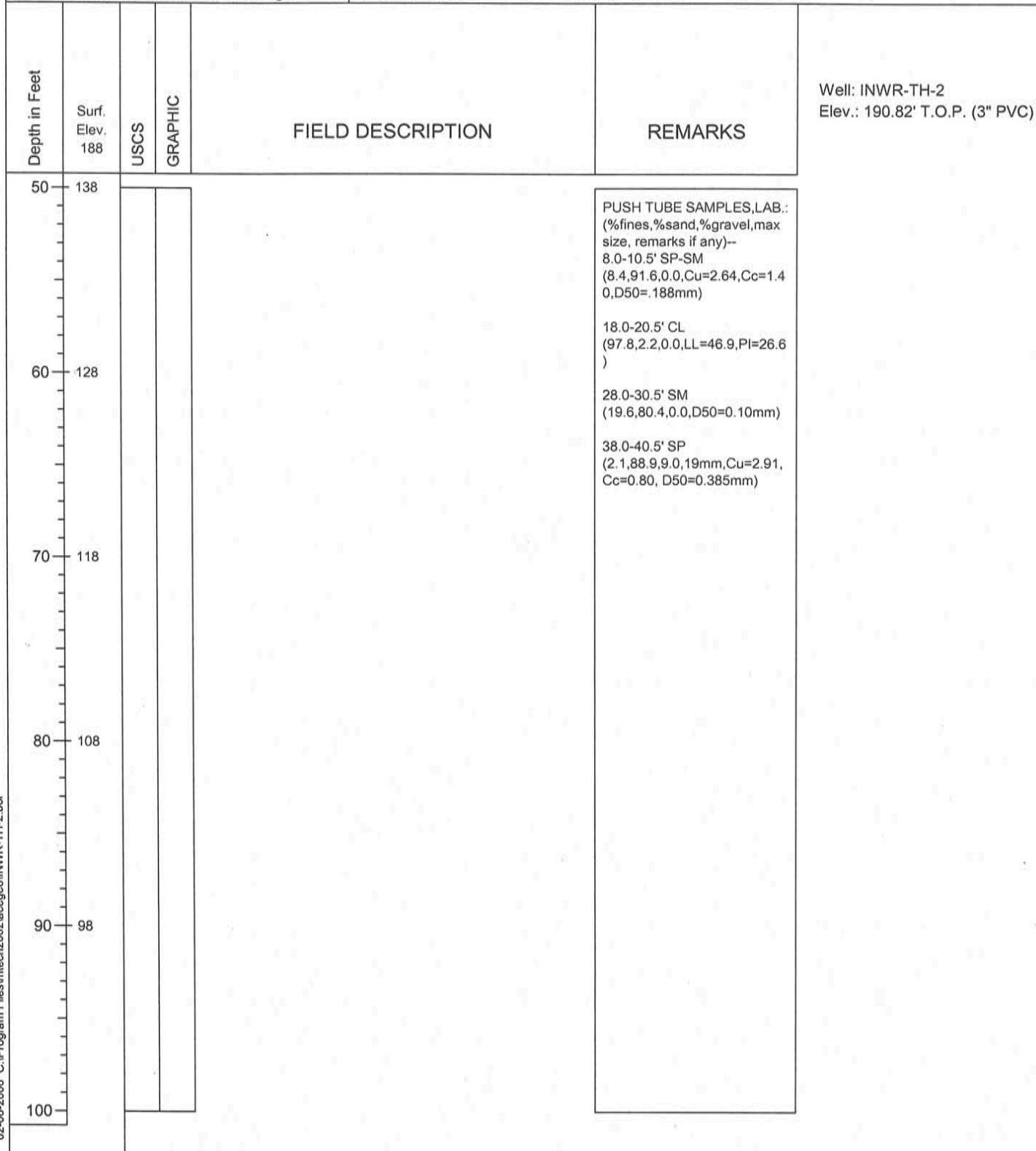




Imperial National Wildlife Refuge TH-2 ADWR 55-209305

(Page 2 of 2)

Bureau of Reclamation Yuma Projects Office Yuma, Arizona	Date Started : 1-18-2006 Date Completed : 1-24-2006 Hole Diameter : 8" 0-40' Drilling Method : 8" Hollowstem Logging Method : Drilling character; samples	Driller : USBR, Yuma Area Office Northing Coord. : 3653338.1 (NAD 27, Easting Coord. : 734238.9 m Zone 11) Logged by: TFox Approved by:
Test Holes for Water Supply Wells for Fish Ponds Imperial National Wildlife Refuge		



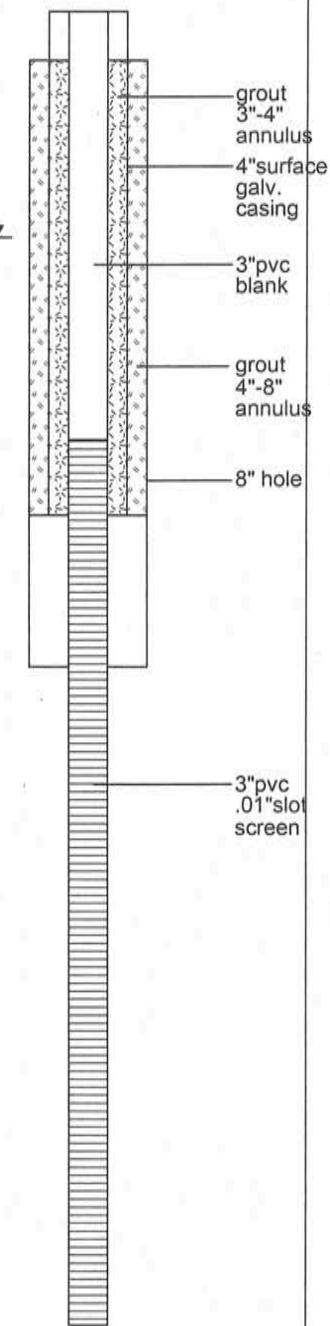


Imperial National Wildlife Refuge TH-4 ADWR 55-209308

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Bureau of Reclamation Yuma Projects Office Yuma, Arizona	Date Started : 1-9-2006 Date Completed : 1-11-2006 Hole Diameter : 8" 0-24'; 4" 24 - 99' Drilling Method : 8" Hollowstem; 4" mudrotary Logging Method : Action; samples; geophysical	Driller : USBR, Yuma Area Office Northing Coord. : 3652574.0 m (NAD 27, Easting Coord. : 735011.6 m Zone 11) Logged by: FCroxen; EBurnett Approved by:
Test Holes for Water Supply Wells for Fish Ponds Imperial National Wildlife Refuge		

Depth in Feet	Surf. Elev. 187	USCS GRAPHIC	FIELD DESCRIPTION	REMARKS	Well: INWR-TH-4 Elev.: 189.54' T.O.P. (3" PVC)
0 - 187			0 - 5' SILTY SAND (SM); moist; brown; about 60% fine sand, about 40 % fines. Grass at surface. Scattered rounded gravel in vicinity at surface.	GPS data is NAD27 conus, Zone 11.	
		SM	5 - 10' SILTY SAND (SM); wet; brown; about 60% fine sand; about 40% fines	Elevation data is NGVD29.	
10 - 177		SW	10 - 11' GRAVELLY SAND (SW); about 60% sand, 35% gravel, 5% red clay; rounded Colorado River type gravel to 1" diameter. Permeable	Arizona Location: (C-5-22)13cdb	
		SM	11 - 13' SILTY SAND (SM); indicated by drilling character and recovered material.	8" hollowstem auger hole from 0 - 24' depth; 4" diam. mud rotary hole from 24' to 99' depth using 3-cone rock bit.	
		SP	13 - 14' SAND (SP); wet; brown; about 95% sand, 5% fines.	Installed 3" I.D. schedule 40 threaded flush-joint pvc pipe as follows, from bottom to top: cap+80' 10-slot screen + 17' blank, stickup = 2.1' above land surface.	
		SW	14 - 24' GRAVELLY SAND (SW); about 60% sand, 40% rounded Colorado River type gravels.	Land surface elev.= 187.4'. Elev. top of 3" pvc = 189.54'. Elevations' datum=NGVD29.	
20 - 167				Installed 20' of 4" I.D. galvanized steel surface pipe, stickup=2' +/-, grouted.	
30 - 157		SP	24 - 32' SAND(SP); indicated by drilling character, recovered material, and geophysical logs. Rough spots at 27' and 28'.	Placed and cemented 5' of steel 6" diam. blue surface pipe with locking cap. Elev. top of 6" pipe, cap open = 189.67" (NGVD29).	
40 - 147		SP	32 - 64' SAND (SP); mostly sand indicated by drilling character, recovered material, and geophysical logs.	Water surface elev. inside 3" pvc = 182.57' on Jan. 20, 2006 at 4 pm.	
50				Not test pumped.	

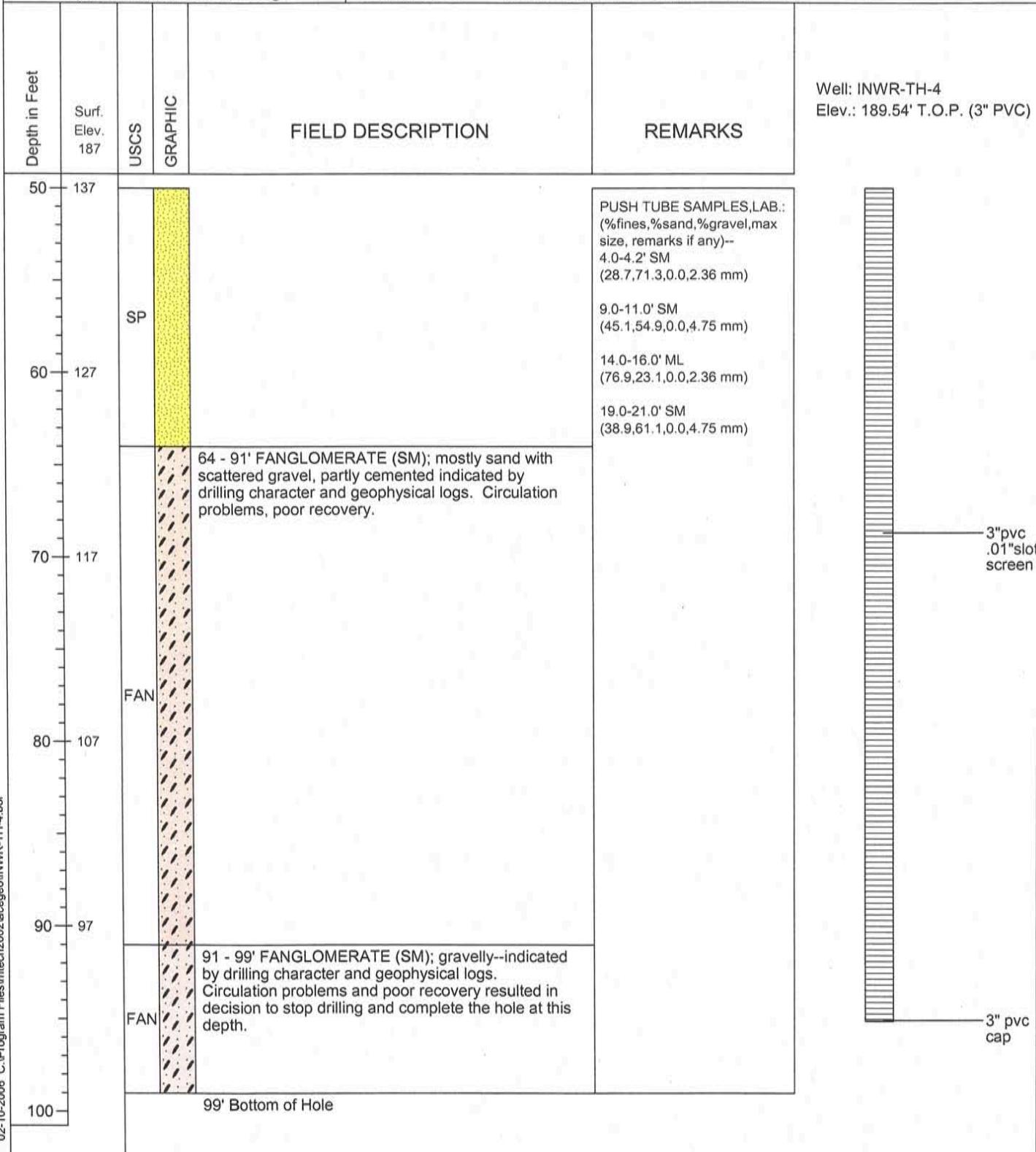




Imperial National Wildlife Refuge TH-4 ADWR 55-209308

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Bureau of Reclamation Yuma Projects Office Yuma, Arizona	Date Started : 1-9-2006 Date Completed : 1-11-2006 Hole Diameter : 8" 0-24'; 4" 24 - 99' Drilling Method : 8" Hollowstem; 4" mudrotary Logging Method : Action; samples; geophysical	Driller : USBR, Yuma Area Office Northing Coord. : 3652574.0 m (NAD 27, Easting Coord. : 735011.6 m Zone 11) Logged by: FCroxen; EBurnett Approved by:
Test Holes for Water Supply Wells for Fish Ponds Imperial National Wildlife Refuge		

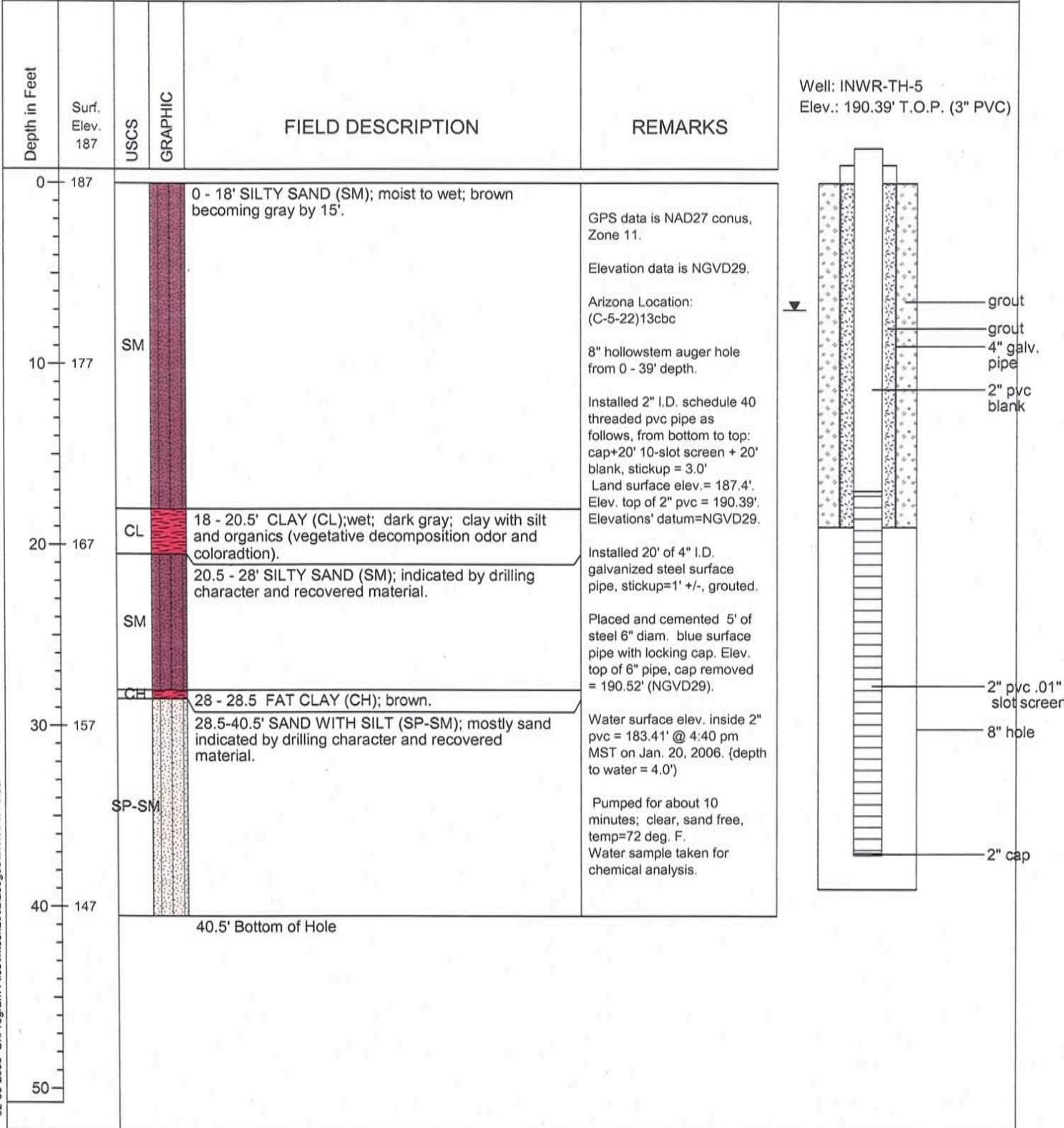




Imperial National Wildlife Refuge TH-5 ADWR 55-209309

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Bureau of Reclamation Yuma Projects Office Yuma, Arizona	Date Started : 1-17-2006 Date Completed : 1-18-2006 Hole Diameter : 8" 0-39 Drilling Method : 8" Hollowstem Logging Method : Drilling character; samples	Driller : USBR, Yuma Area Office Northing Coord. : 3652620.6 m (NAD 27, Easting Coord. : 734531.0 m Zone 11) Logged by: TFox Approved by:
Test Holes for Water Supply Wells for Fish Ponds Imperial National Wildlife Refuge		





Imperial National Wildlife Refuge TH-5 ADWR 55-209309

(Page 2 of 2)

Bureau of Reclamation Yuma Projects Office Yuma, Arizona	Date Started : 1-17-2006 Date Completed : 1-18-2006 Hole Diameter : 8" 0-39 Drilling Method : 8" Hollowstem Logging Method : Drilling character; samples	Driller : USBR, Yuma Area Office Northing Coord. : 3652620.6 m (NAD 27, Easting Coord. : 734531.0 m Zone 11) Logged by: TFox Approved by:
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Test Holes for Water Supply Wells for Fish Ponds

Imperial National Wildlife Refuge

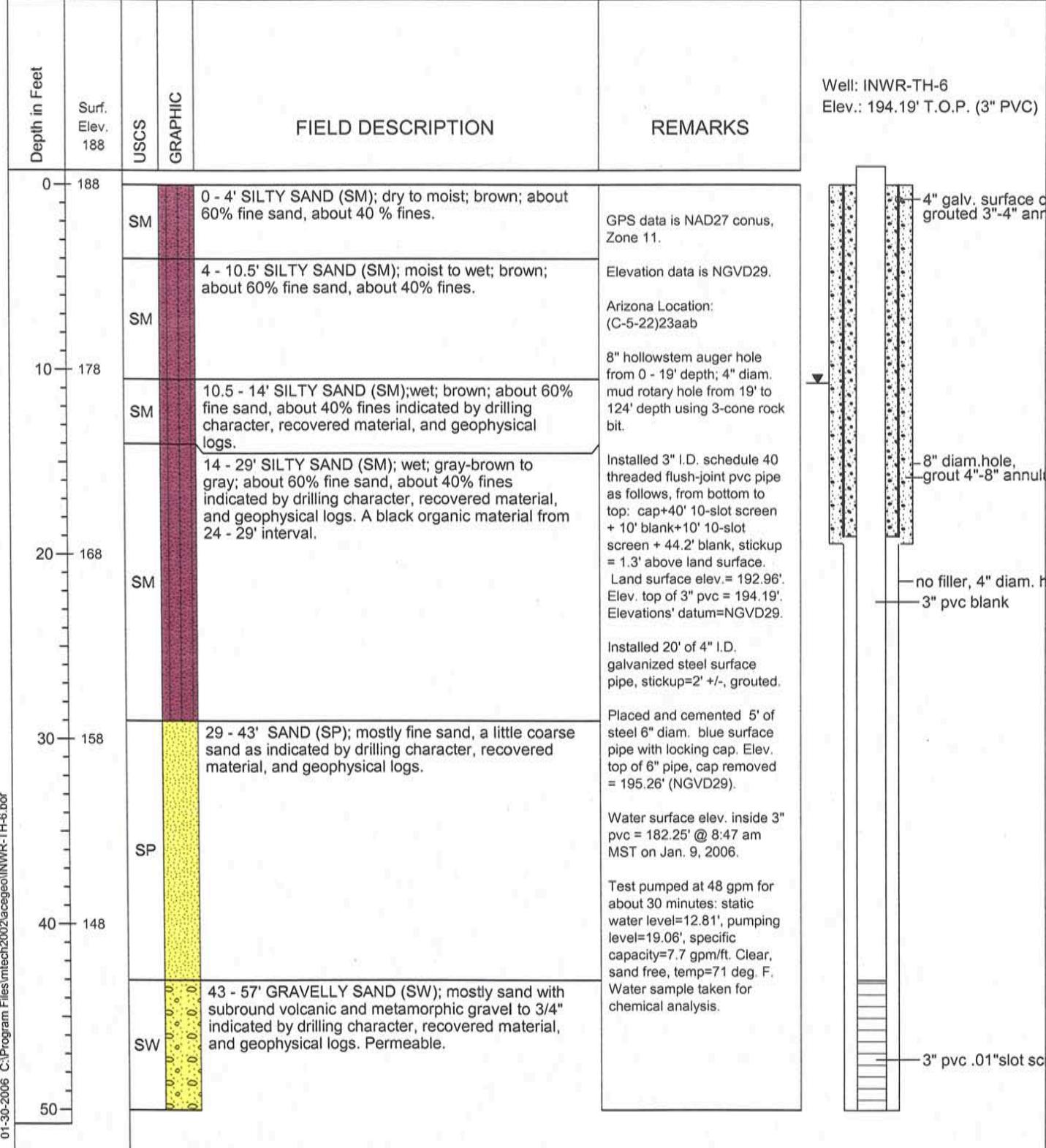
Depth in Feet	Surf. Elev. 187	USCS	GRAPHIC	FIELD DESCRIPTION	REMARKS	Well: INWR-TH-5 Elev.: 190.39' T.O.P. (3" PVC)
50	137				PUSH TUBE SAMPLES,LAB.: (%fines,%sand,%gravel,max size, remarks if any)--	
60	127				7.0' SM (16.3,83.7,0.0,D50=.106mm, grab sample--not push tube)	
70	117				18.5-20.5' CL (92.9,7.1,0.0,LL=46.0,PI=26.4)	
80	107				28.0-28.5' CH (95.8,4.2,0.0,LL=53.8,PI=33.8)	
90	97				28.5-30.5' SP-SM (10.2,89.8,0.0,D50=0.128mm)	
100					38.5-40.5' SP-SM (7.4,92.3,0.3,D50=0.157mm, Cu=2.31,Cc=0.88)	



Imperial National Wildlife Refuge TH-6 ADWR 55-209310

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Bureau of Reclamation Yuma Projects Office Yuma, Arizona	Date Started : 12-28-2005 Date Completed : 1-5-2006 Hole Diameter : 8" 0'-19'; 4" 19' - 124' Drilling Method : 8" Hollowstem; 4" mudrotary Logging Method : Action; samples; geophysical	Driller : USBR, Yuma Area Office Northing Coord. : 3652135.2 m (NAD 27, Easting Coord. : 734167.4 m Zone 11) Logged by: FCroxen; EBurnett Approved by:
Test Holes for Water Supply Wells for Fish Ponds Imperial National Wildlife Refuge		



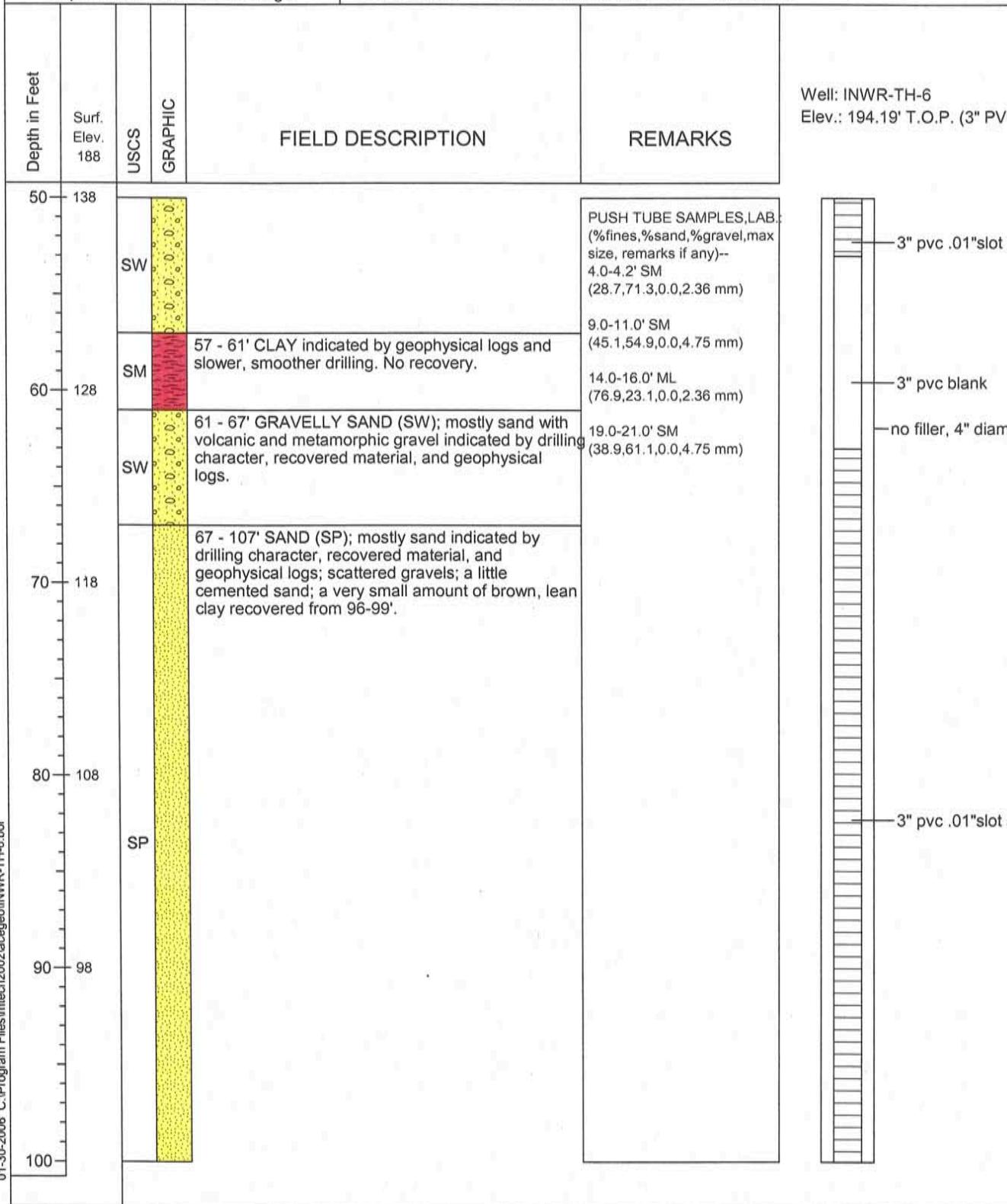


Imperial National Wildlife Refuge TH-6 ADWR 55-209310

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Bureau of Reclamation Yuma Projects Office Yuma, Arizona	Date Started : 12-28-2005 Date Completed : 1-5-2006 Hole Diameter : 8" 0'-19'; 4" 19' - 124'	Driller : USBR, Yuma Area Office Northing Coord. : 3652135.2 m (NAD 27, Easting Coord. : 734167.4 m Zone 11)
Test Holes for Water Supply Wells for Fish Ponds	Drilling Method : 8" Hollowstem; 4" mudrotary Logging Method : Action; samples; geophysical	Logged by: FCroxen; EBurnett Approved by:

Imperial National Wildlife Refuge





Imperial National Wildlife Refuge TH-6 ADWR 55-209310

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Bureau of Reclamation
Yuma Projects Office
Yuma, Arizona

Date Started : 12-28-2005 Driller : USBR, Yuma Area Office
Date Completed : 1-5-2006 Northing Coord. : 3652135.2 m (NAD 27,
Hole Diameter : 8" 0'-19'; 4" 19 - 124' Easting Coord. : 734167.4 m Zone 11)
Drilling Method : 8" Hollowstem; 4" mudrotary Logged by: FCroxen; EBurnett
Logging Method : Action; samples; geophysical Approved by:

Test Holes for Water Supply Wells for Fish Ponds
Imperial National Wildlife Refuge

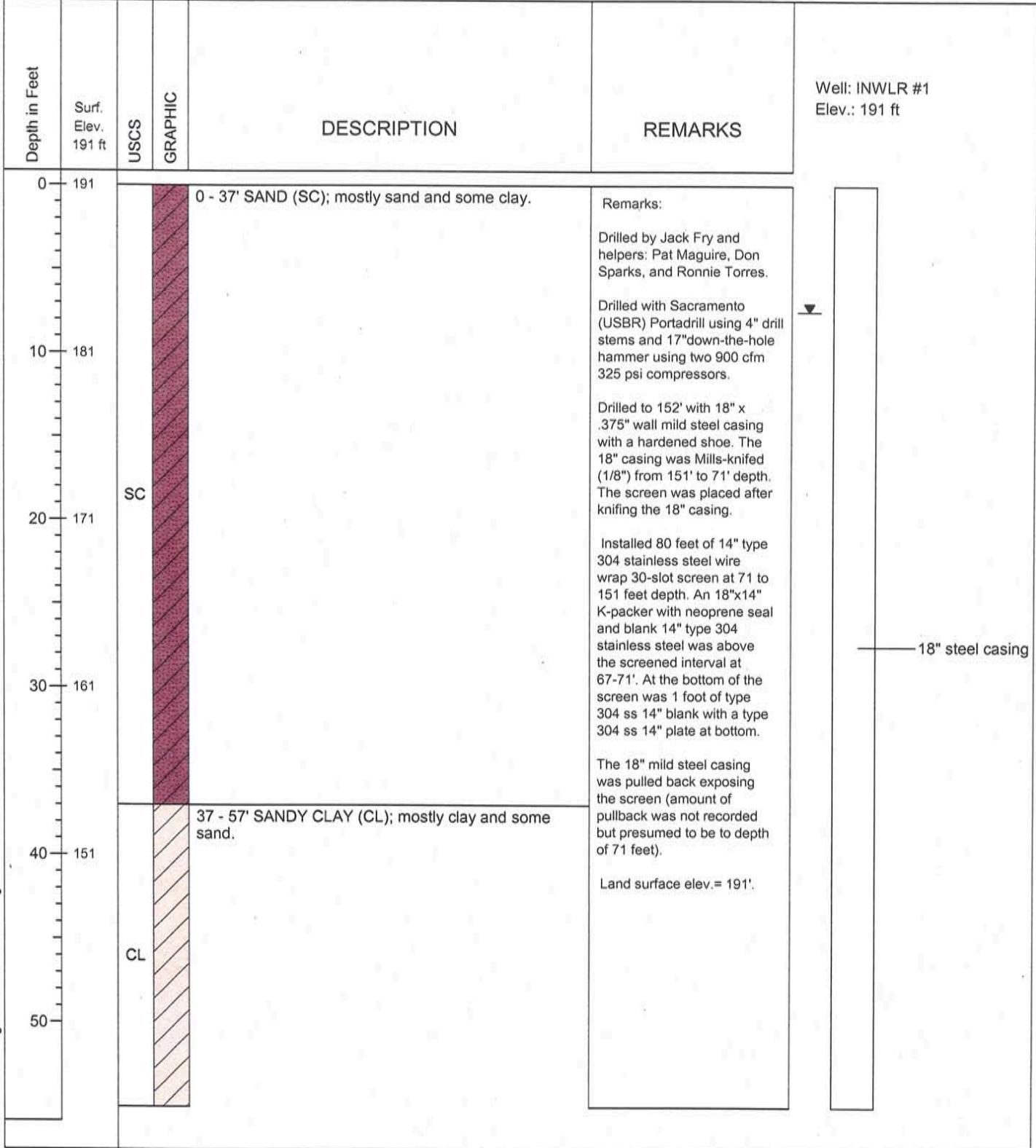
Depth in Feet	Surf. Elev. 188	USCS	GRAPHIC	FIELD DESCRIPTION	REMARKS	
100	88					Well: INWR-TH-6 Elev.: 194.19' T.O.P. (3" PVC)
110	78	SP		107 - 108' CLAY; indicated by geophysical logs and drilling character. No recovery.		— no filler, 4" diam. hole
120	68	SP		108 - 112' SAND (SP); mostly sand with some cementation indicated by drilling character, recovered material, and geophysical logs.		3" pvc .01"slot screen,cap@botto
130	58	SW		112 - 119' GRAVELLY SAND (SW); indicated by drilling character, recovered material, and geophysical logs.		
140	48	SP		119 - 124' SAND (SP); smooth drilling; sand indicated by drilling character, recovered material, and geophysical logs.		
150				124' Bottom of Hole		



INWR #1, ADWR 55-?

(Page 1 of 3)

Bureau of Reclamation Yuma Projects Office Yuma, Arizona	Date Started : 5-13-1999 Date Completed : 5-19-1999 Hole Diameter : 17" bit Drilling Method : Air; down-hole-hammer Logging Method : samples from discharge	Driller : Jack Fry (USBR-Denver) Northing Coord. : 3653674 m (NAD 27, Easting Coord. : 734461 m Zone 11) Location : (C-5-22)14aaaa1 Logged By : USBR
Water Supply Wells		
Imperial National Wildlife Refuge		





INWR #1, ADWR 55-?

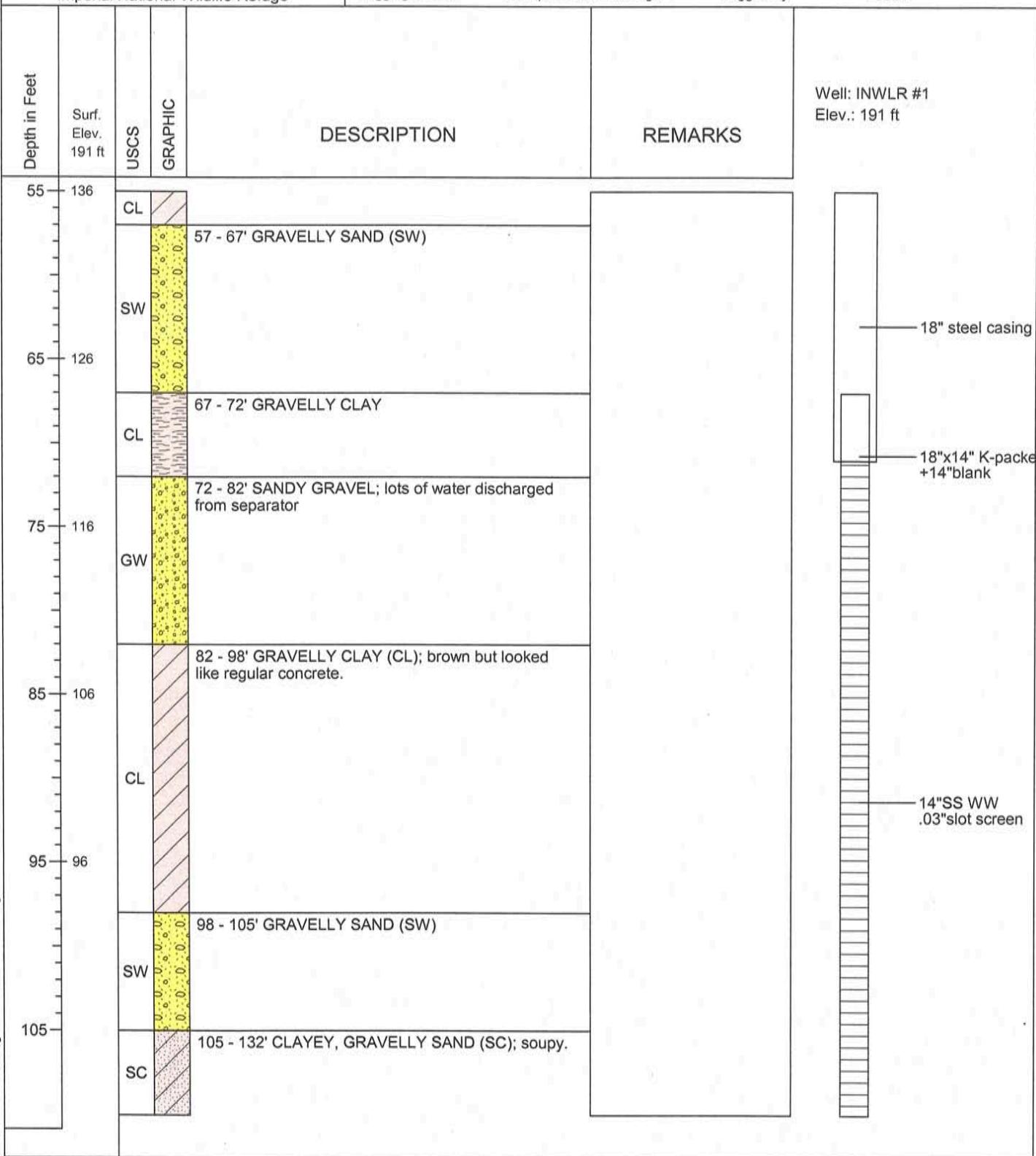
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Bureau of Reclamation
Yuma Projects Office
Yuma, Arizona

Water Supply Wells

Imperial National Wildlife Refuge

Date Started	: 5-13-1999	Driller	: Jack Fry (USBR-Denver)
Date Completed	: 5-19-1999	Northing Coord.	: 3653674 m (NAD 27,
Hole Diameter	: 17" bit	Easting Coord.	: 734461 m Zone 11)
Drilling Method	: Air; down-hole-hammer	Location	: (C-5-22)14aaaa1
Logging Method	: samples from discharge	Logged By	: USBR





INWR #1, ADWR 55-?

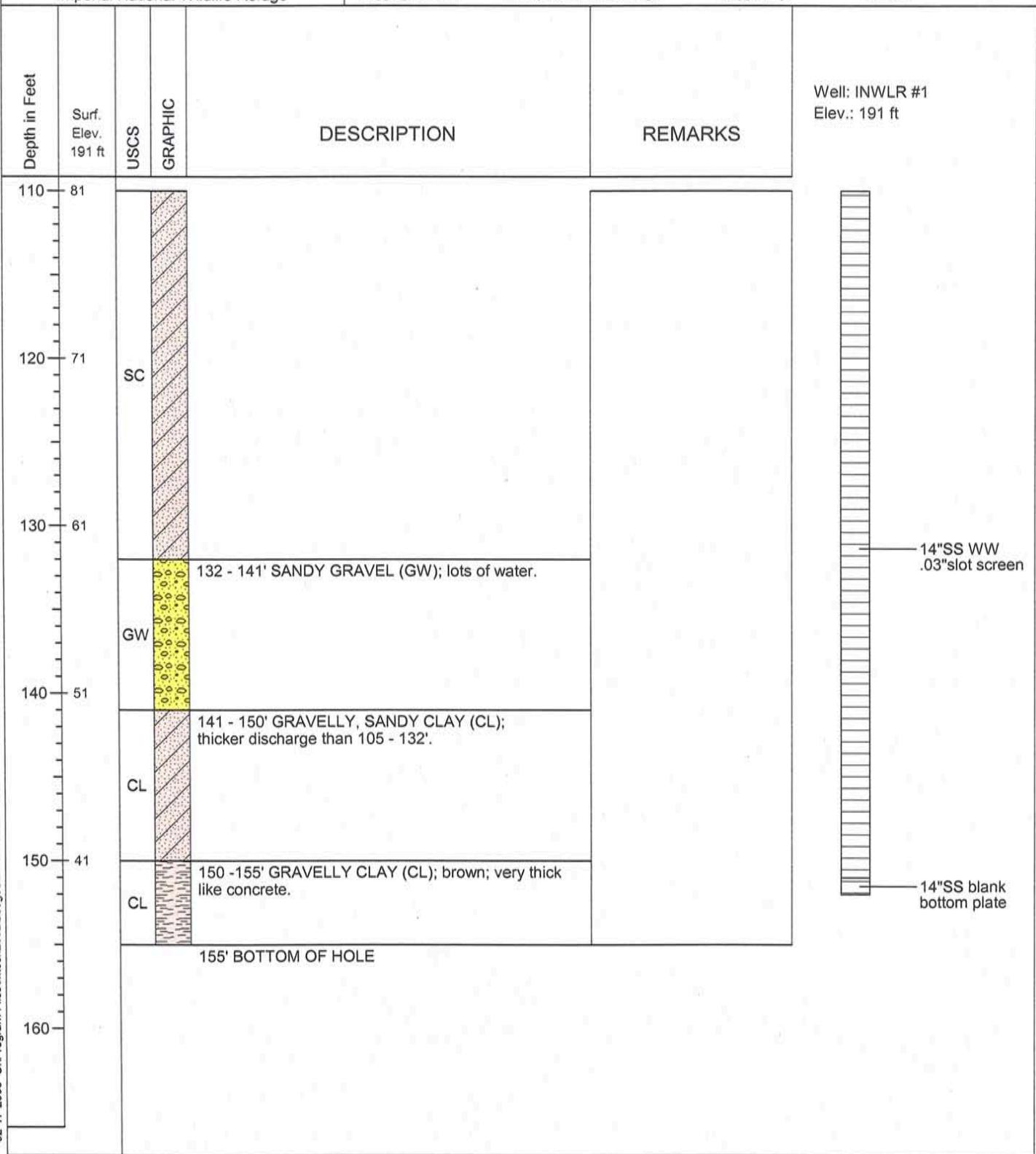
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Bureau of Reclamation
Yuma Projects Office
Yuma, Arizona

Water Supply Wells
Imperial National Wildlife Refuge

Date Started : 5-13-1999
Date Completed : 5-19-1999
Hole Diameter : 17" bit
Drilling Method : Air; down-hole-hammer
Logging Method : samples from discharge

Driller : Jack Fry (USBR-Denver)
Northing Coord. : 3653674 m (NAD 27,
Easting Coord. : 734461 m Zone 11)
Location : (C-5-22)14aaaa1
Logged By : USBR





Imperial Nat'l Wildlife Refuge Well #2, ADWR 55-591281

"South" Well

(Page 1 of 3)

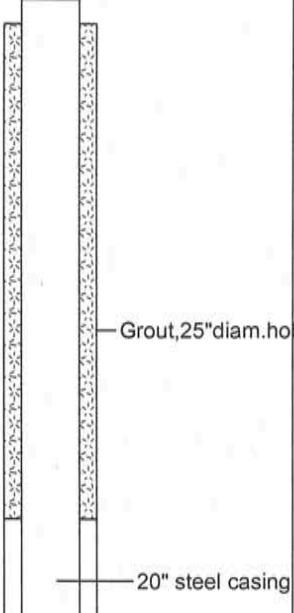
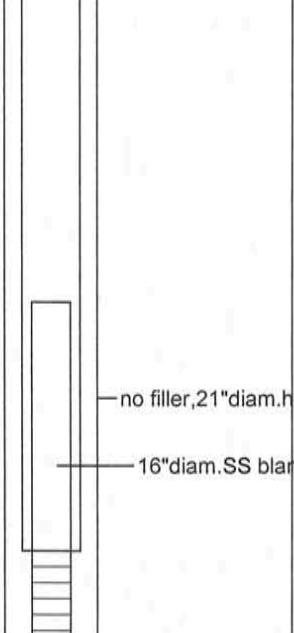
Bureau of Reclamation
Yuma Projects Office
Yuma, Arizona

Water Supply Wells

Imperial National Wildlife Refuge

Date Started : 5-2-2002
Date Completed : 5-6-2002
Hole Diameter : 25" 0'-20'; 21" 20'-136'.
Drilling Method :
Logging Method : Lab. analysis of samples

Driller :
Northing Coord. : 3653657.6 m (NAD 27,
Easting Coord. : 734467.6 m Zone 11)
Location : (C-5-22)14aaa
Logged By :

Depth in Feet	Surf. Elev. 190	USCS GRAPHIC	DESCRIPTION	REMARKS	
0 - 190			SILTY SAND (SM); 75% sand, 25% fines. D60=.1103mm, D50=.099mm, D30=.0796mm, MAX size #8 - #16.	Well Diagram: 25" diam. hole from 0 - 20' depth; 21" diam. hole from 20' to 136' depth. Grout placed from 0 - 20' depth. No filler used in annular space from 20' to 136' depth.	
10 - 180	180	SM		Installed 47' of 20" steel blank surface casing with 1' of pickup above land surface. Placed grout in annulus from 0 to 20' depth. Installed 10' of 16" diam. type 304 stainless steel blank from 36' to 46' depth. Installed 90' of 16" diam. type 304 stainless steel screen, 20-slot (.020" width) from 46' to 136' depth below land surface. No filler used in annulus from 20' to 136' depth. Land surface elev. = 190'.	
20 - 170	170	ML	SILT WITH SAND (ML); 79% fines, 21% sand; MAX size #8 - #16		
30 - 160	160	SM	SILTY SAND (SM); 73.2% sand, 26.5% fines, 0.3% gravel; D60=.1646 mm, D50=.1275 mm, D30=.0812 mm, MAX size 3/8" - #4		
30 - 160	160	SP-SM	POORLY GRADED SAND WITH SILT (SP-SM); 89.3% sand, 9.0% fines, 1.7% gravel; D60=.3173 mm, D50=.2397 mm, D30=.1308 mm, D10=.077 mm; Cu=4.121, Cc=.700		
40 - 150	150	SM	SILTY SAND (SM); 83.9% sand, 12.5% fines, 3.6% gravel; D60=.342 mm, D50=.2581 mm, D30=.1524 mm, MAX size 3/4" - 3/8"		
40 - 150	150	SW	WELL GRADED SAND WITH GRAVEL (SW); 65.9% sand, 29.8% gravel, 4.3% fines; D60=3.0657 mm, D50=2.0234 mm, D30=.7062 mm, D10=.1551 mm; MAX size 3/4" - 3/8"; Cu=19.766; Cc=1.049		
50 -		SW-SM	WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM); 68.0% sand, 23.5% gravel, 8.5% fines; D60=2.0559 mm, D50=1.2788 mm, D30=.4763 mm, D10=.1028 mm. MAX 3/4" - 3/8"; Cu=19.999; Cc=1.073		
50 -		SP	Poorly GRADED SAND WITH GRAVEL (SP); 71.1% sand, 27.2% gravel, 1.7% fines; D60=2.242 mm, D50=1.557 mm, D30=.7034 mm, MAX 3/4" - 3/8"; Cu=7.351; Cc=.724		



Imperial National Wildlife Refuge Well #2, ADWR 55-591281

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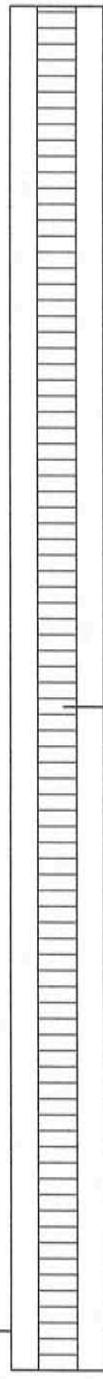
Bureau of Reclamation
Yuma Projects Office
Yuma, Arizona

Water Supply Wells

Imperial National Wildlife Refuge

Date Started	: 5-2-2002	Driller	:
Date Completed	: 5-6-2002	Northing Coord.	: 36536657.6 m (NAD 27,
Hole Diameter	: 25" 0-20'; 21" 20'-136'.	Easting Coord.	: 734467.6 m Zone 11)
Drilling Method	:	Location	: (C-5-22)14aaa
Logging Method	: Lab. analysis of samples	Logged By	:

Depth in Feet	Surf. Elev. 190	USCS GRAPHIC	DESCRIPTION	REMARKS
55	135	SP	POORLY GRADED SAND WITH GRAVEL (SP); 73.0%, 25.1%, 1.9%; D60=2.1537 mm, D50=1.4926 mm, D30=.7077 mm, D10=.3104 mm; MAX 3/4" - 3/8"; Cu=6.938; Cc=.749	
		SW	WELL GRADED SAND WITH GRAVEL (SW); 55.9% sand, 40.5% gravel, 3.6% fines; D60=4.803 mm, D50=3.4407 mm, D30=1.5722 mm, D10=.3901 mm; MAX 3/4" - 3/8"; Cu=12.312; Cc=1.319.	
65	125	SM	SILTY SAND WITH GRAVEL (SM); 57.2%, 30.3%, 12.5%; D60=3.1792 mm, D50=1.9437 mm, D30=.2870 mm, D10=N/A. MAX 3/4" - 3/8".	
		SM	SILTY SAND (SM); 66.6% sand, 25.5% fines, 7.9% gravel; D60=.2288, D50=.167 mm, D30=.0869, D10=N/A; MAX 3/4" - 3/8".	
75	115	SM	WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM); 61.9% sand, 32.9% gravel; 5.2% fines; D60=3.763 mm, D50=2.7087 mm, D30=1.3102 mm, D10=.1974 mm; MAX 1.5" - .75"; Cu=19.063, Cc=2.311	
		SP	POORLY GRADED SAND WITH GRAVEL (SP); 75.3% sand, 22.8% gravel, 1.9% fines; MAX 3/4" - 3/8"; D60=1.5197 mm, D50=.686 mm, D30=.3368 mm, D10=.1724 mm; Cu=8.815; Cc=.433	
85	105	SP	POORLY GRADED SAND WITH GRAVEL (SP); 75.1% sand, 20.9% gravel, 4.0% fines; MAX 3/4" - 3/8"; D60=2.3518 mm, D50=1.6064 mm, D30=.6165 mm, D10=.1876 mm; Cu=12.536; Cc=.861	
		SP-SM	POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM); 71.9% sand, 16.8% gravel, 11.3% fines; MAX 3/4" - 3/8"; D60=1.2182 mm, D50=.7541 mm, D30=.324 mm, D10= N/A	
95	95	SP	POORLY GRADED SAND WITH GRAVEL (SP); 78.1% sand, 20.1% gravel, 1.8% fines; MAX 3/4" - 3/8"; D60=1.8047 mm, D50=1.1602 mm, D30=.5889 mm, D10=.3171 mm; Cu=5.691; Cc=.606	
		SP	POORLY GRADED SAND (SP); 85.1% sand, 13.9% gravel, 1.0% fines; MAX 3/4" - 3/8"; D60=1.0633 mm, D50=.8140 mm, D30=.4928 mm, D10=.3119 mm; Cu=3.409; Cc=.732	
105	105	SP	POORLY GRADED SAND WITH GRAVEL (SP); 58.0% sand, 41.7% gravel, 0.3% fines; MAX 3/4" - 3/8"; D60=4.9073 mm, D50=3.4819 mm, D30=1.5646 mm, D10=.6477 mm; Cu=7.577; Cc=.770	
				Well: INWLR #2 Elev.: 190.4



16"SS WW .02"slot screener
— no filler, 21" diam. hole



Imperial National Wildlife Refuge Well #2, ADWR 55-591281

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Bureau of Reclamation
Yuma Projects Office
Yuma, Arizona

Water Supply Wells

Imperial National Wildlife Refuge

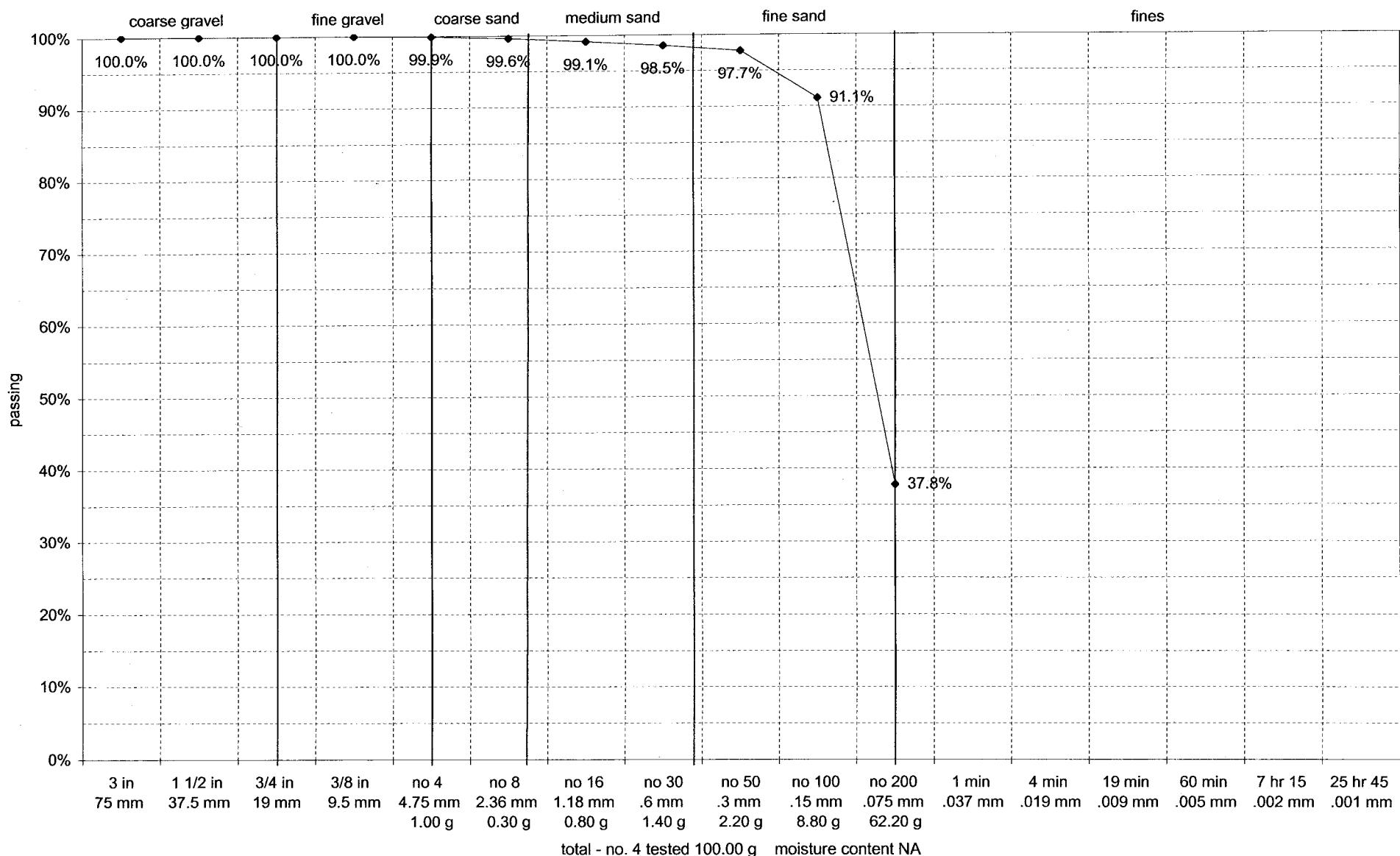
Date Started	: 5-2-2002	Driller	:
Date Completed	: 5-6-2002	Northing Coord.	: 36536657.6 m (NAD 27,
Hole Diameter	: 25" 0'-20'; 21" 20'-136".	Easting Coord.	: 734467.6 m Zone 11)
Drilling Method	:	Location	: (C-5-22)14aaa
Logging Method	: Lab. analysis of samples	Logged By	:

Depth in Feet	Surf. Elev. 190	USCS GRAPHIC	DESCRIPTION	REMARKS
110	80	SP	POORLY GRADED SAND WITH GRAVEL (SP); 69.7% sand, 28.1% gravel, 2.2% fines; MAX 3/4" - 3/8"; D60=2.7277 mm, D50=1.6378 mm, D30=.6485 mm, D10=.301 mm; Cu=9.062; Cc=.512	
		SP	POORLY GRADED SAND WITH GRAVEL (SP); 75.7% sand, 23.1% gravel, 1.2% fines; MAX 3/4" - 3/8"; D60=2.046 mm, D50=1.3266 mm, D30=.5708 mm, D10=.2836 mm	
120	70	SP	POORLY GRADED SAND WITH GRAVEL (SP); 76.9% sand, 21.2% gravel, 1.9% fines; MAX 3/4" - 3/8"; D60=.8392 mm, D50=.5629 mm, D30=.3994 mm D10=.2333 mm; Cu=3.597; Cc=.815	
		SP	POORLY GRADED SAND WITH GRAVEL (SP); 60.2% sand, 39.5% gravel, 0.3% fines; MAX 3/4" - 3/8"; D60=4.6709 mm, D50=3.3528 mm, D30=1.6367 mm, D10=.5792 mm; Cu=8.064; Cc=.99	
130	60	SP	POORLY GRADED SAND WITH GRAVEL (SP); 76.8% sand, 22.8% gravel, 0.4% fines; MAX 3/4" - 3/8"; D60=1.8736 mm, D50=1.0939 mm, D30=.4911 mm, D10=.2623 mm; Cu=7.143; Cc=.491	
		SP	POORLY GRADED SAND (SP); 88.8% sand, 10.7% gravel, 0.5% fines; MAX 3/4" - 3/8"; D60=.7696 mm, D50=.576 mm, D30=.3745 mm, D10=.1971 mm; Cu=3.905; Cc=.925	
140	50	SM	SILTY SAND (SM); 62.9% sand, 34.4% fines, 2.7% gravel; MAX 3/4" - 3/8"; D60=.3826 mm, D50=.2289 mm, D30= N/A, D10= N/A.	
150	40	SM	SILTY SAND WITH GRAVEL (SM); 50.9% sand, 31.7% gravel, 17.4% fines; MAX 3/4" - 3/8"; D60=3.4649 mm, D50=2.3683 mm, D30=.5521 mm, D10= N/A.	
			BOTTOM OF HOLE, 155 FEET.	
160				

APPENDIX II
GRADATIONS

2.0 - 4.0 ft Test Hole 1 Imperial National Wildlife Refuge 12-19-2005

total dry wt tested 1,000.00 g SM; Silty sand. Total weights entered as constants for percentage replication.

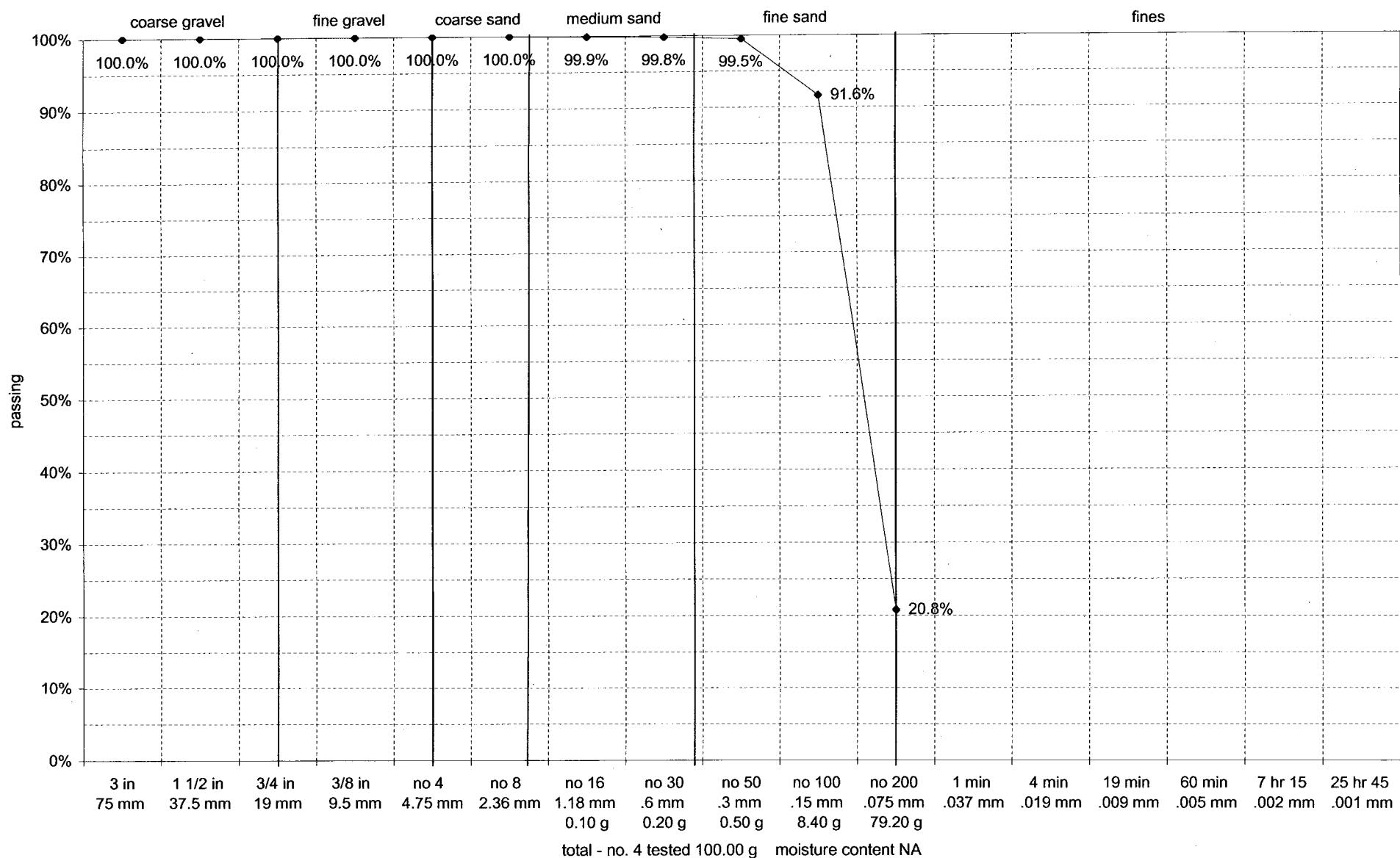


Coef. of uniformity NA Coef. of curvature NA D60: 0.100 mm D50: 0.0879 mm D30: NA D10: NA

Gravel 0.1 % Sand 62.1 % Fines 37.8 %

9.0 - 10.5 ft Test Hole 1 Imperial National Wildlife Refuge 12-19-2005

total dry wt tested 1,000.00 g SM; Silty sand. Total weights entered as constants for percentage replication.



Coef. of uniformity NA

Coef. of curvature NA

D60: 0.110 mm

D50: 0.0998 mm

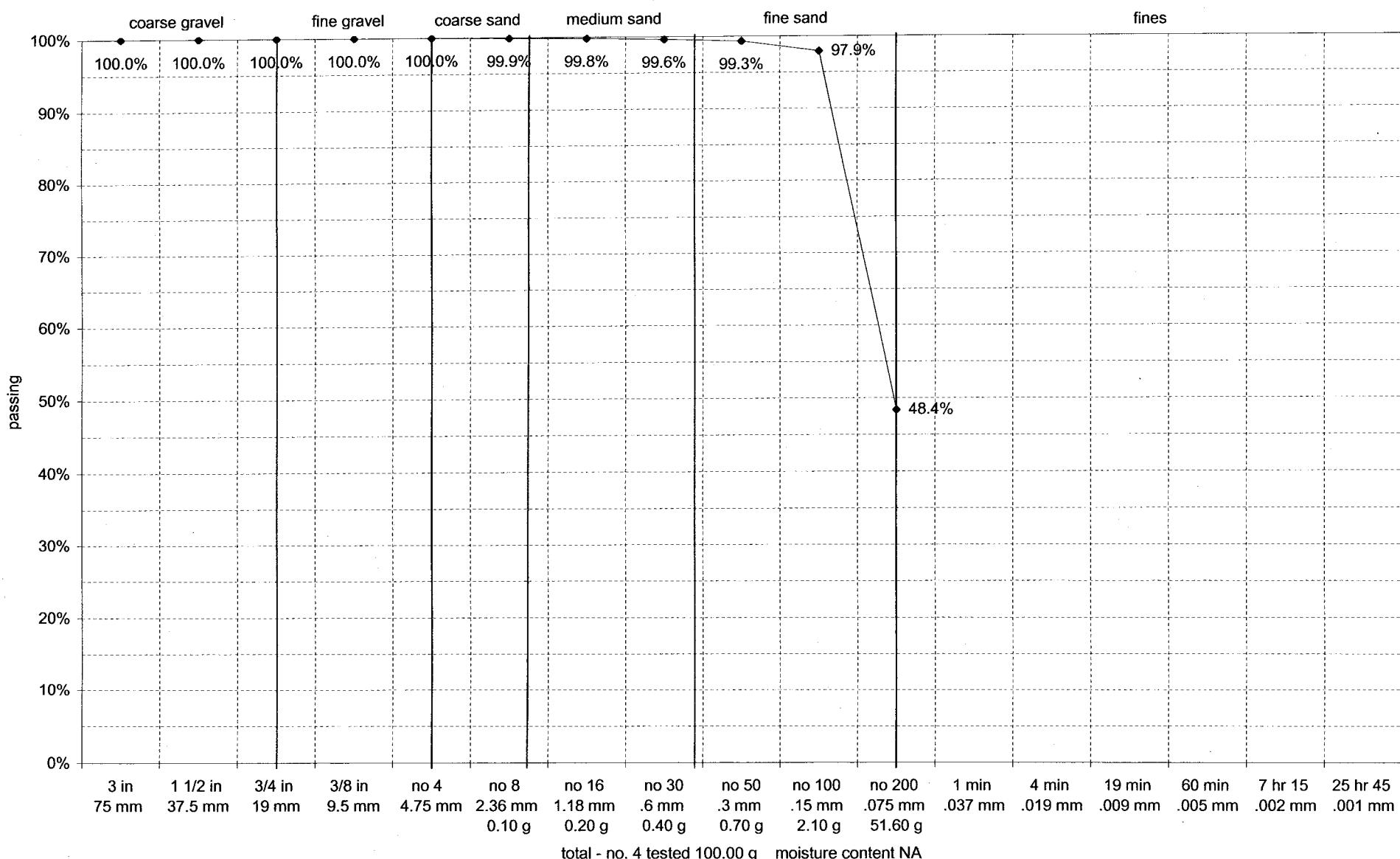
D30: 0.0821 mm

D10: NA

Gravel 0.0 % Sand 79.2 % Fines 20.8 %

10.5 - 11.0 ft Test Hole 1 Imperial National Wildlife Refuge 12-19-2005

total dry wt tested 1,000.00 g SM; Silty sand. Total weights entered as constants for percentage replication.

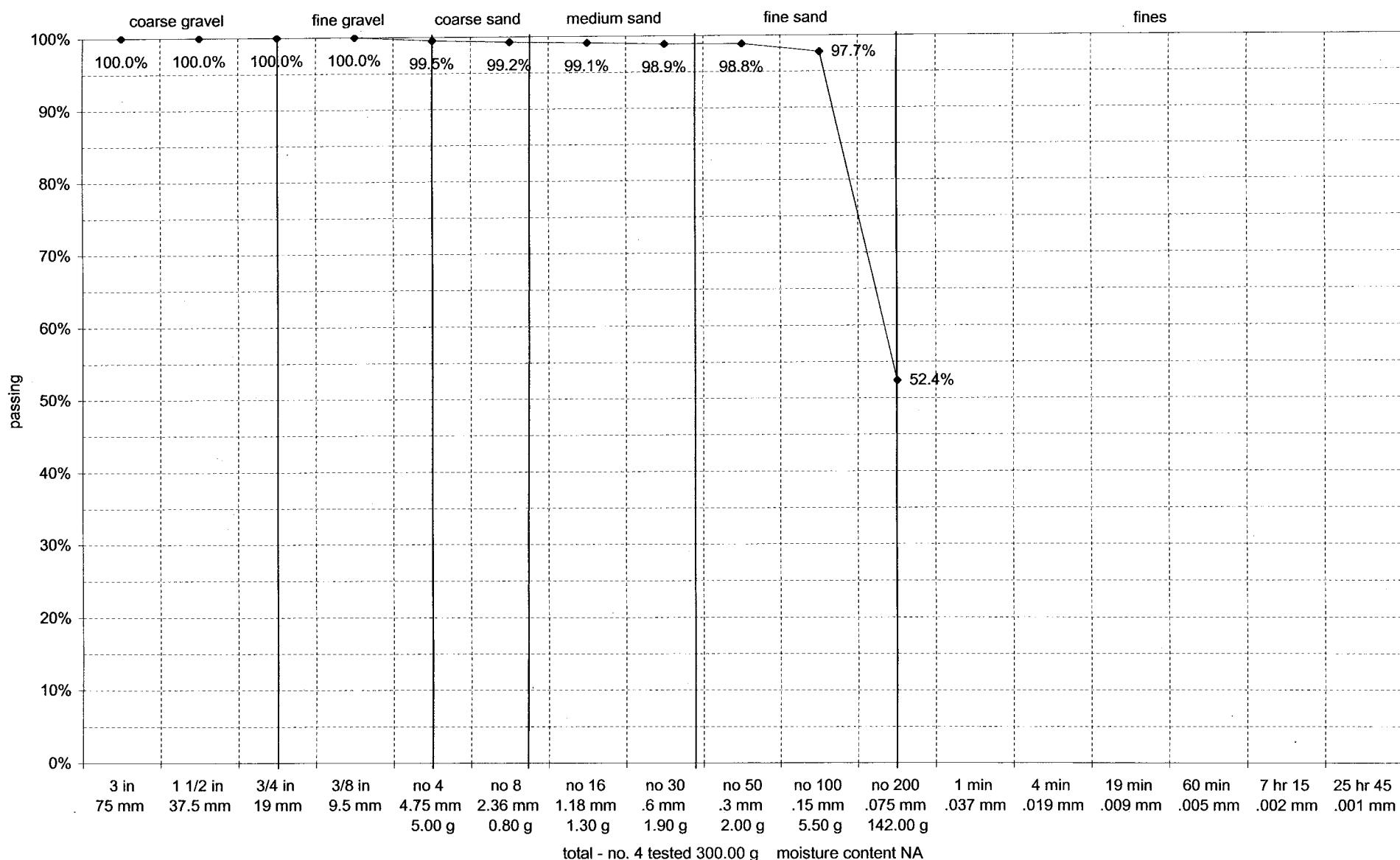


Coef. of uniformity NA Coef. of curvature NA D60: 0.0882 mm D50: 0.0767 mm D30: NA D10: NA

Gravel 0.0 % Sand 51.6 % Fines 48.4 %

14.0 - 16.0 ft Test Hole 1 Imperial National Wildlife Refuge 12-19-2005

total dry wt tested 1,000.00 g ML; Sandy silt. Total weights entered as constants for percentage replication.



Coef. of uniformity NA

Coef. of curvature NA

D60: 0.0843 mm

D50: NA

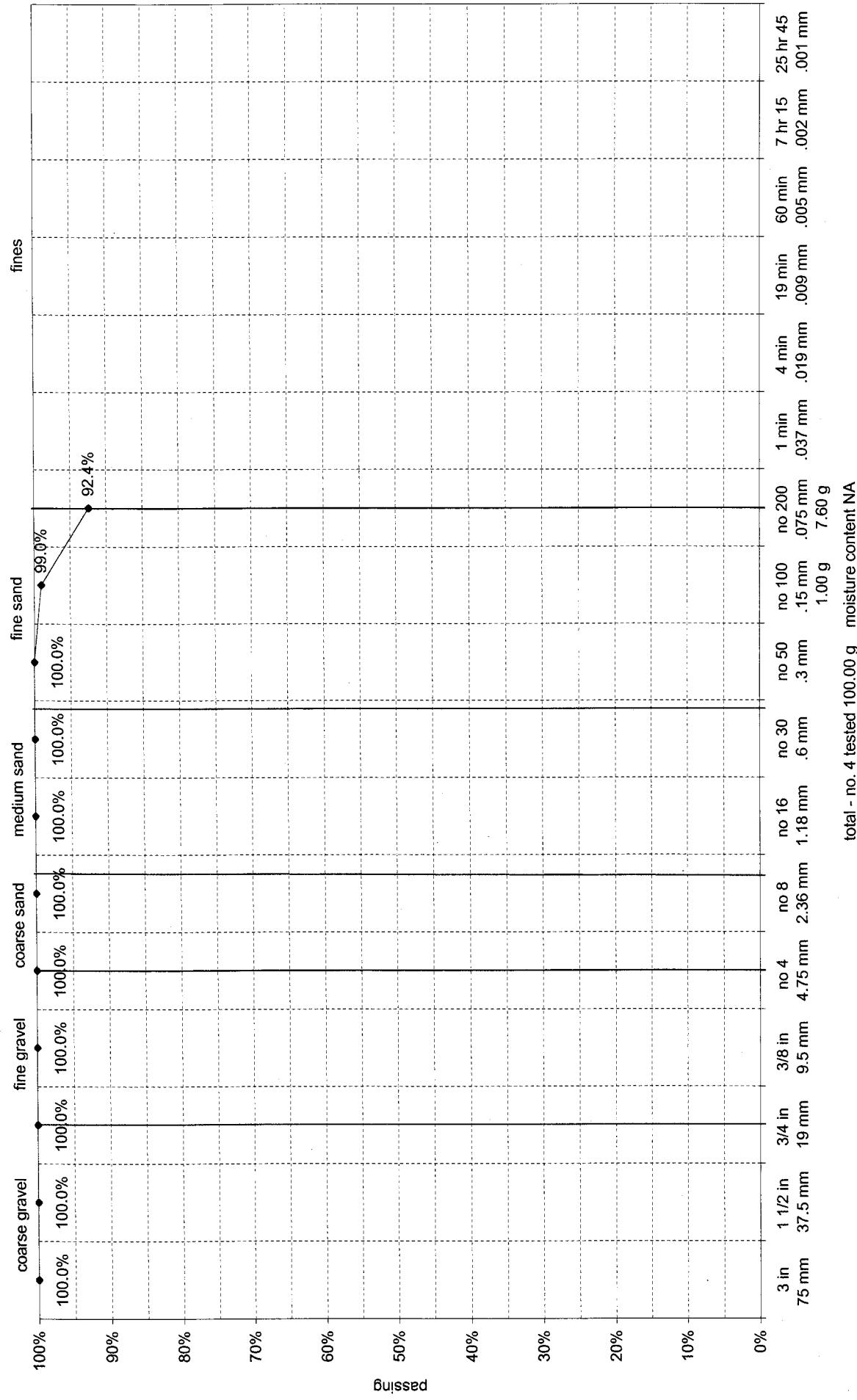
D30: NA

D10: NA

Gravel 0.5 % Sand 47.1 % Fines 52.4 %

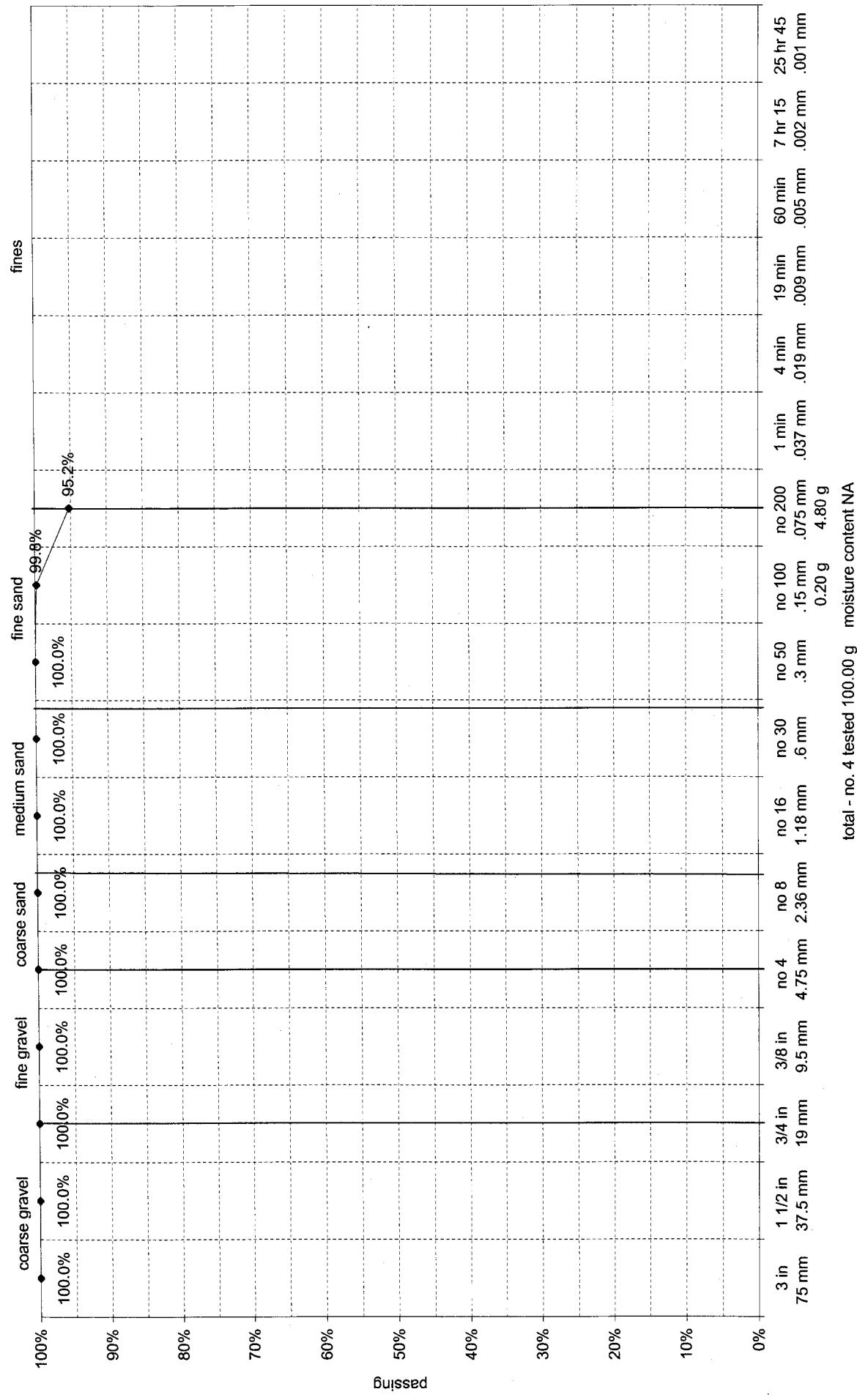
19.0 - 19.8 ft Test Hole 1 Imperial National Wildlife Refuge 12-19-2005

total dry wt tested 1,000.00 g CL; Lean clay. Atterberg test: Liquid Limit = 37.7, Plasticity Index = 23.3. Total weights entered as constants for percentage replication.



19.8 - 20.2 ft Test Hole 1 Imperial National Wildlife Refuge 12-19-2005

total dry wt tested 1,000.00 g ML; Silt. Total weights entered as constants for percentage replication.

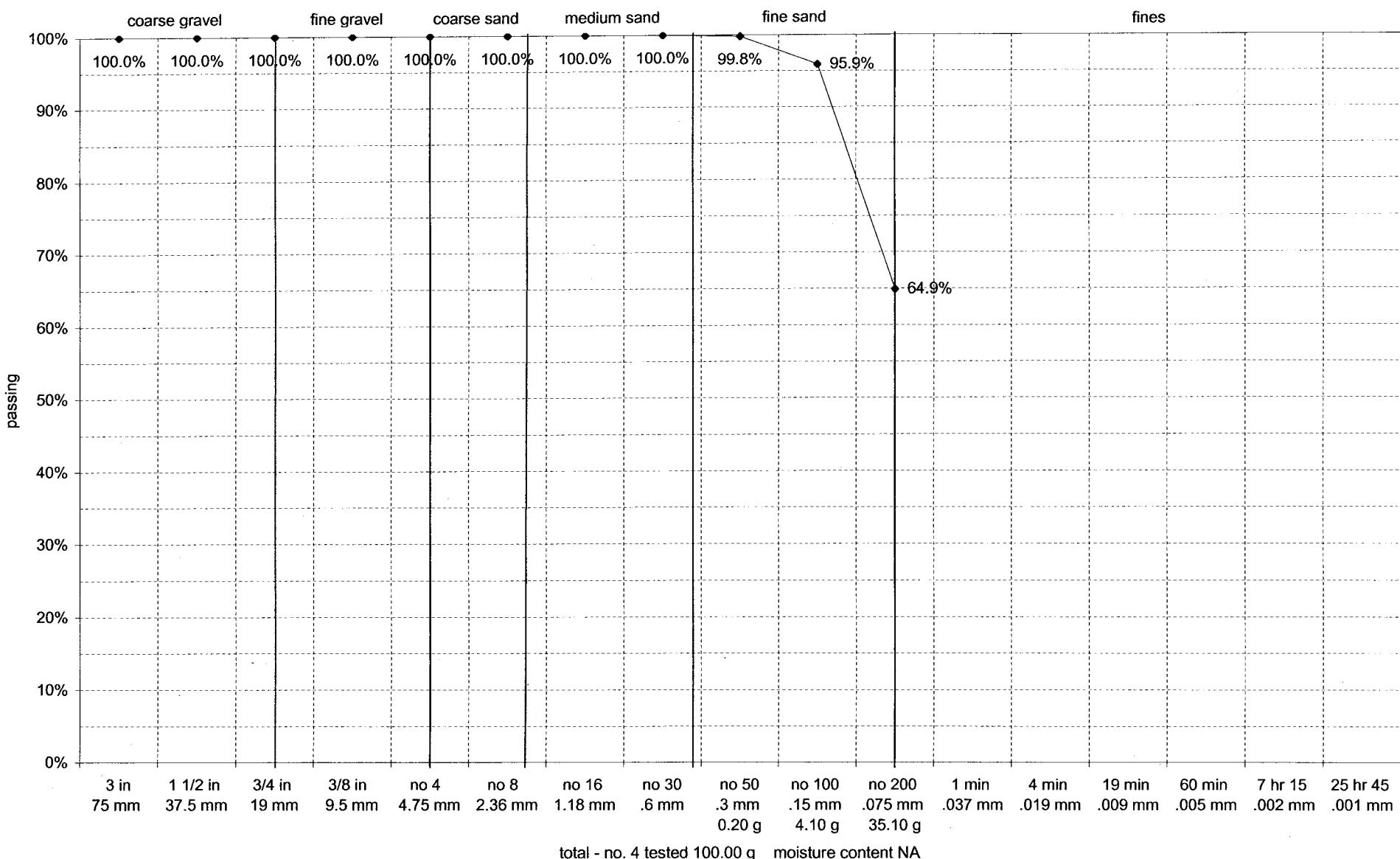


Coef. of uniformity NA Coef. of curvature NA D60: NA D50: NA D30: NA D10: NA

Gravel 0.0 % Sand 4.8 % Fines 95.2 %

20.2 - 20.3 ft Test Hole 1 Imperial National Wildlife Refuge 12-19-2005

total dry wt tested 1,000.00 g ML; Sandy silt. Total weights entered as constants for percentage replication.

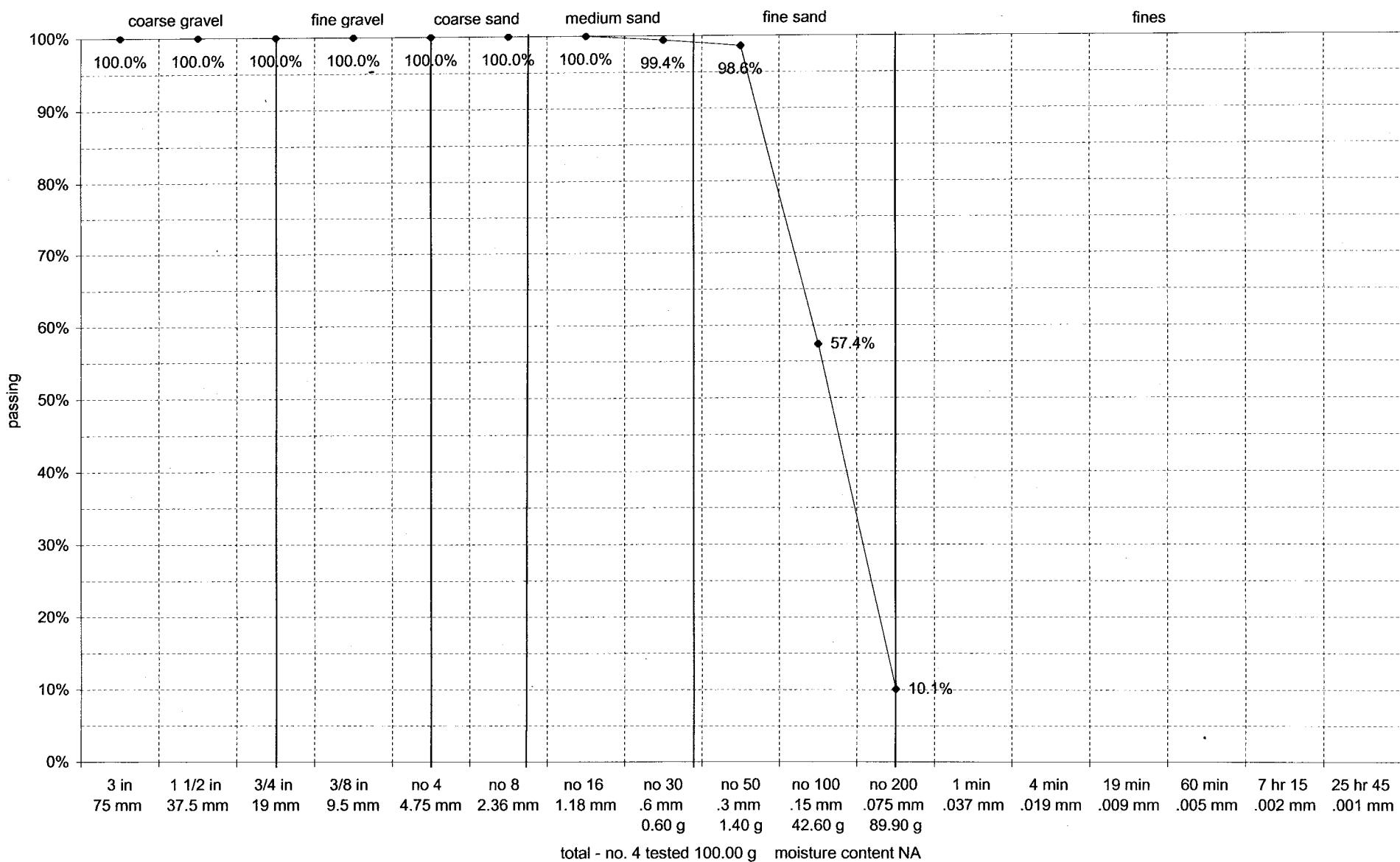


Coef. of uniformity NA Coef. of curvature NA D60: NA D50: NA D30: NA D10: NA

Gravel 0.0 % Sand 35.1 % Fines 64.9 %

28.0 - 29.5 ft Test Hole 1 Imperial National Wildlife Refuge 12-20-2005

total dry wt tested 1,000.00 g SP-SM; Poorly graded sand with silt. Total weights entered as constants for percentage replication.

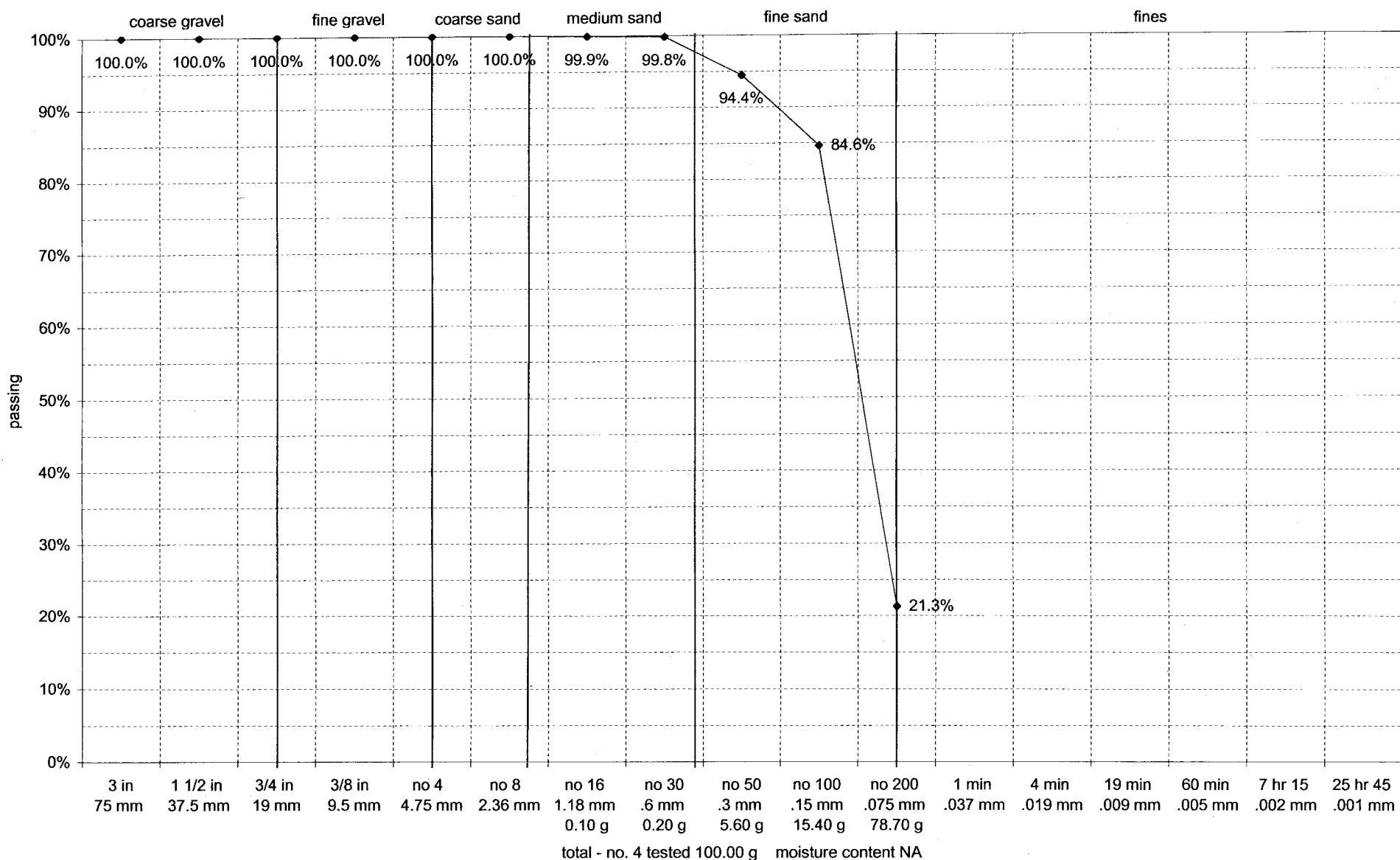


Coef. of uniformity NA Coef. of curvature NA D60: 0.157 mm D50: 0.135 mm D30: 0.100 mm D10: NA

Gravel 0.0 % Sand 89.9 % Fines 10.1 %

29.5 - 30.0 ft Test Hole 1 Imperial National Wildlife Refuge 12-20-2005

total dry wt tested 1,000.00 g SM; Silty sand. Total weights entered as constants for percentage replication.

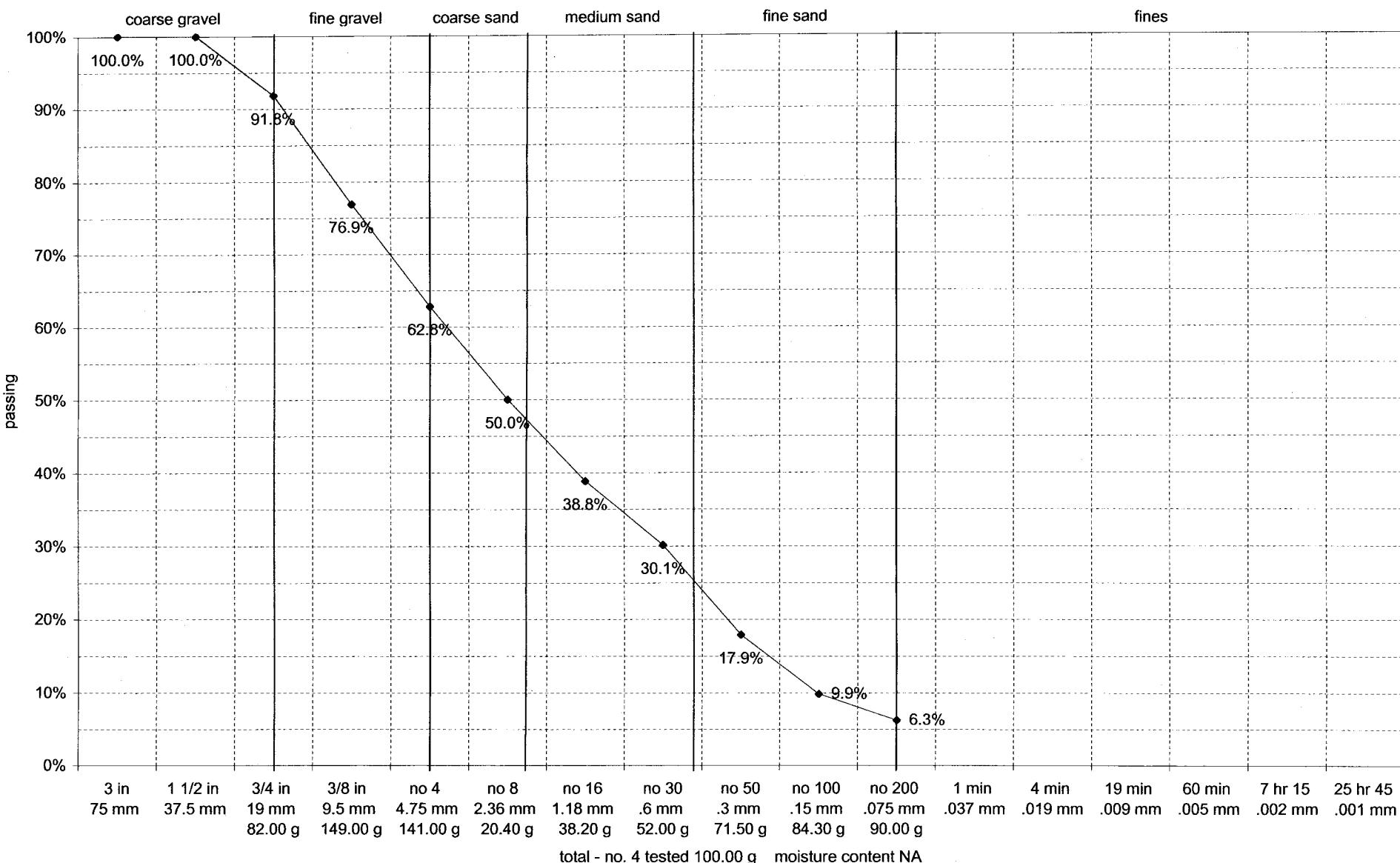


Coef. of uniformity NA Coef. of curvature NA D60: 0.115 mm D50: 0.103 mm D30: 0.0825 mm D10: NA

Gravel 0.0 % Sand 78.7 % Fines 21.3 %

38.0 - 40.0 ft Test Hole 1 Imperial National Wildlife Refuge 12-20-2005

total dry wt tested 1,000.00 g SP-SM; Poorly graded sand with silt and gravel. Total weights entered as constants for percentage replication.

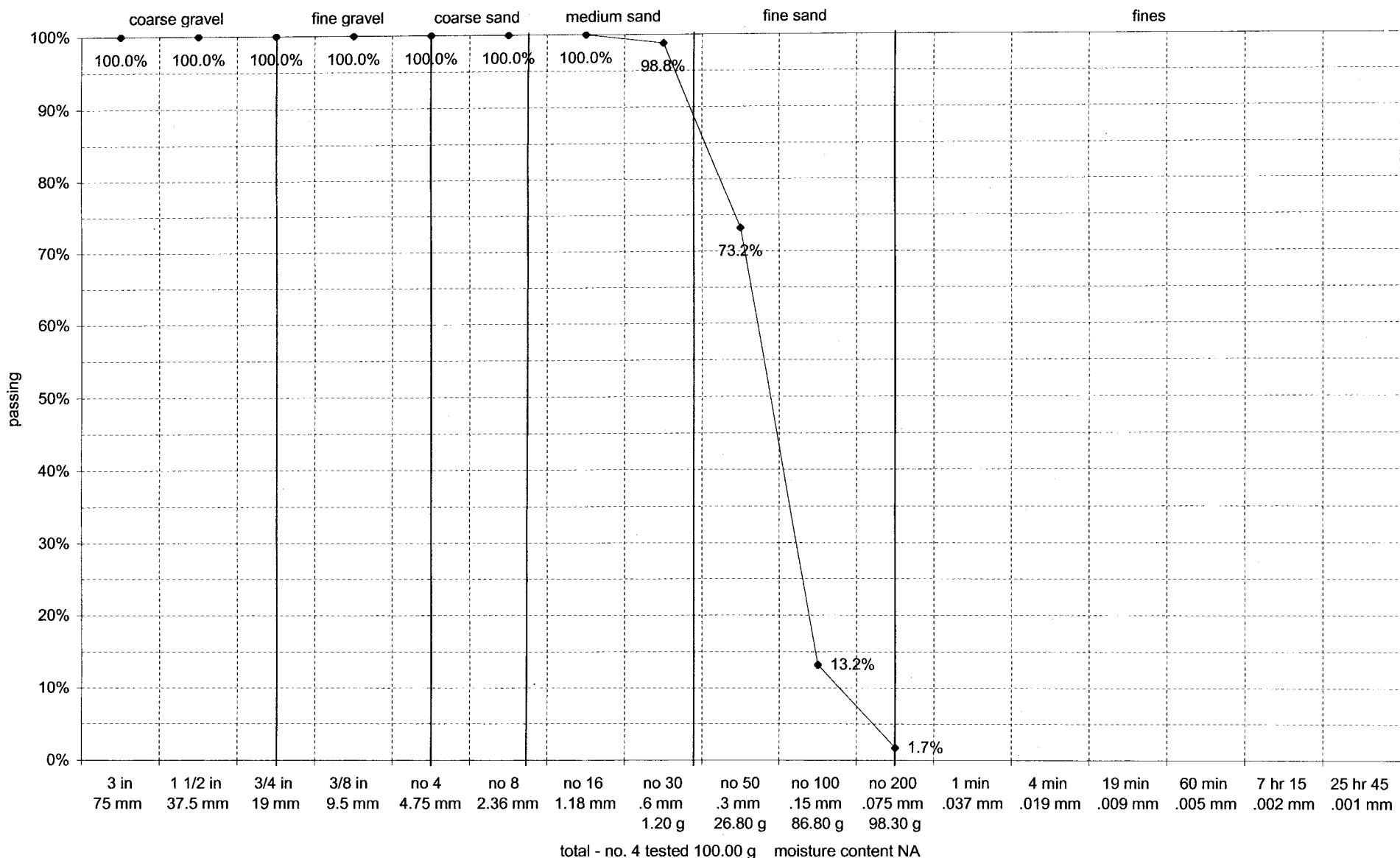


Coef. of uniformity 27.02 Coef. of curvature 0.58 D60: 4.08 mm D50: 2.36 mm D30: 0.597 mm D10: 0.151 mm

Gravel 37.2 % Sand 56.5 % Fines 6.3 %

Generic Sand Test Hole 1 Imperial National Wildlife Refuge 12-27-2005

total dry wt tested 1,000.00 g SP; Poorly graded sand. Collected from material flushed out during well development. Total weights entered as constants for percentage replication.

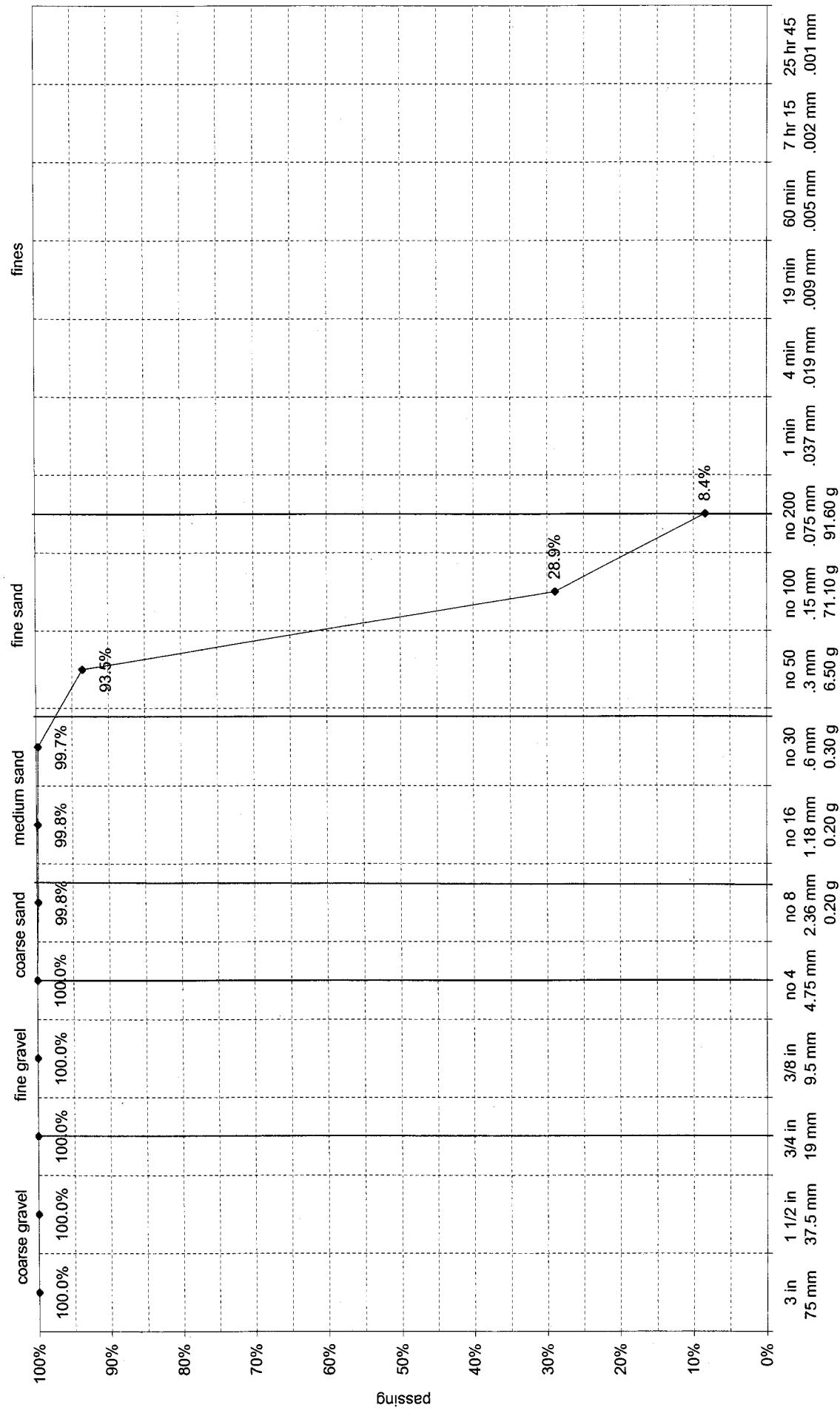


Coef. of uniformity 2.08 Coef. of curvature 1.04 D60: 0.258 mm D50: 0.229 mm D30: 0.182 mm D10: 0.124 mm

Gravel 0.0 % Sand 98.3 % Fines 1.7 %

8.0 - 10.5 ft Test Hole 2 Imperial National Wildlife Refuge 1-18-2006

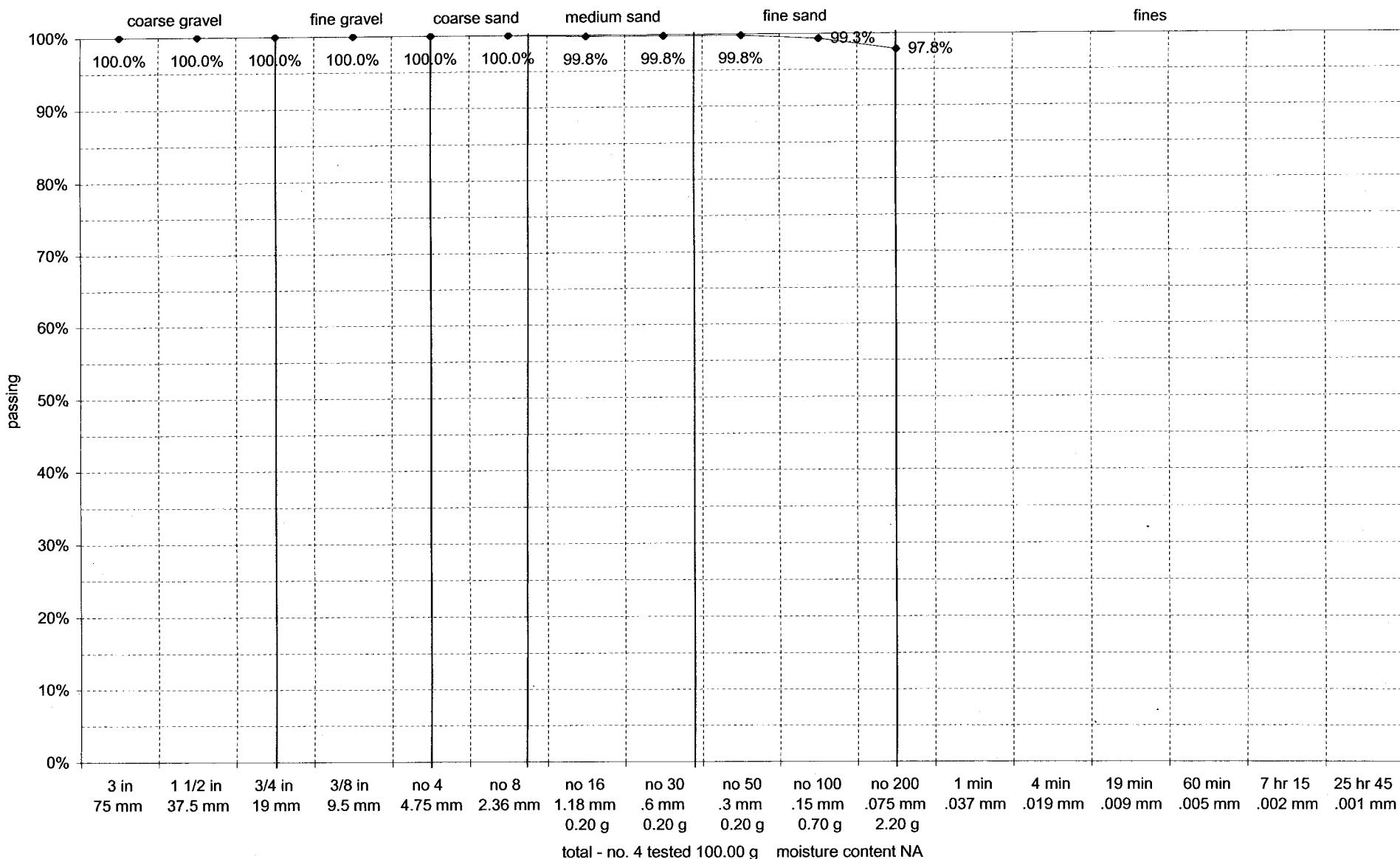
total dry wt tested 1,000.00 g SP-SM; Poorly graded sand with silt. Total weights entered as constants for percentage replication.



Coef. of uniformity 2.64 Coef. of curvature 1.40 D60: 0.209 mm D50: 0.188 mm D30: 0.152 mm D10: 0.0792 mm
 Gravel 0.0 % Sand 91.6 % Fines 8.4 %

18.0 - 20.5 ft Test Hole 2 Imperial National Wildlife Refuge 1-18-2006

total dry wt tested 1,000.00 g CL; Lean clay. Atterberg test: Liquid Limit = 46.9, Plasticity Index = 26.6. Total weights entered as constants for percentage replication.



Coef. of uniformity NA

Coef. of curvature NA

D60: NA

D50: NA

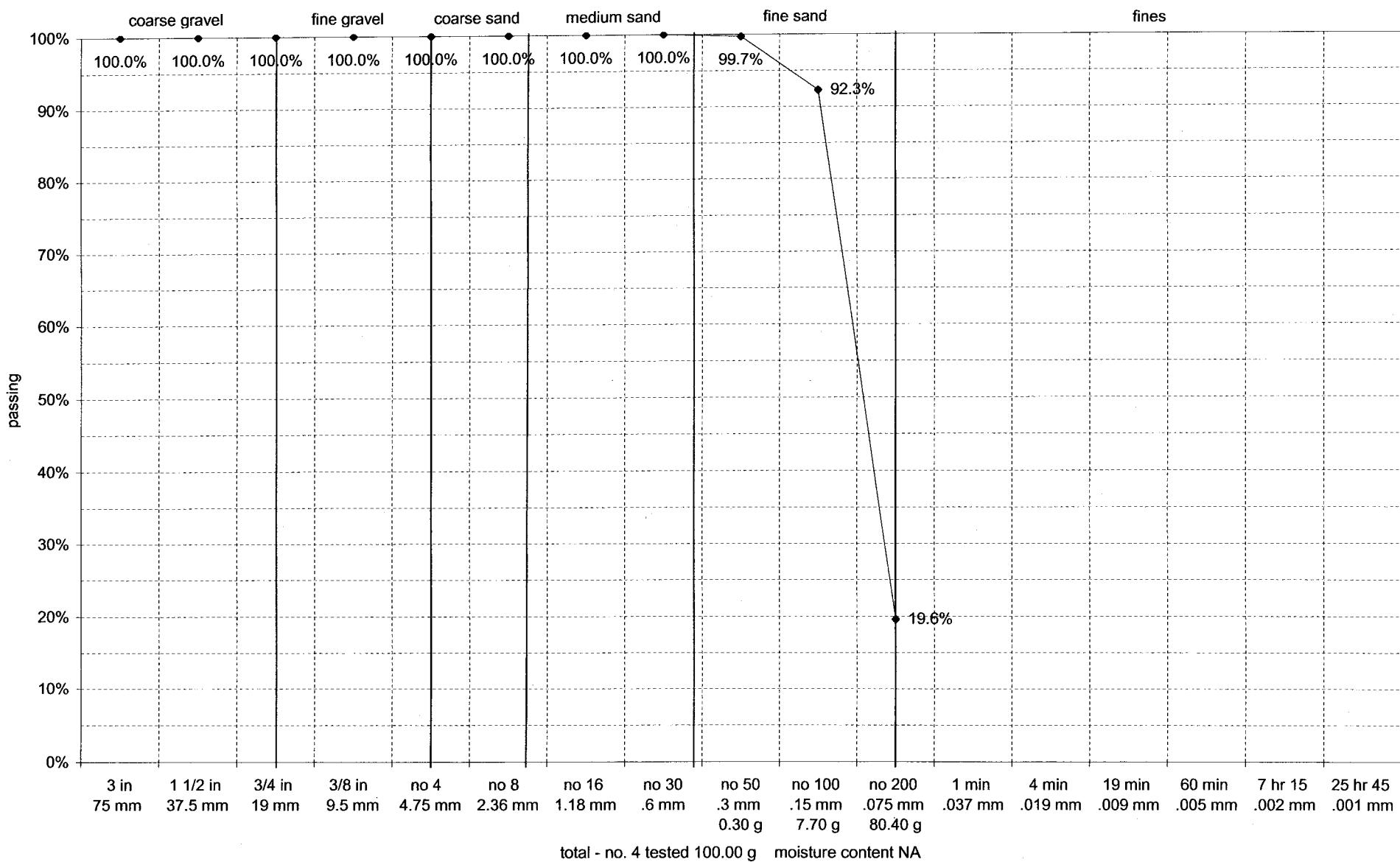
D30: NA

D10: NA

Gravel 0.0 % Sand 2.2 % Fines 97.8 %

28.0 - 30.5 ft Test Hole 2 Imperial National Wildlife Refuge 1-18-2006

total dry wt tested 1,000.00 g SM; Silty sand. Total weights entered as constants for percentage replication.

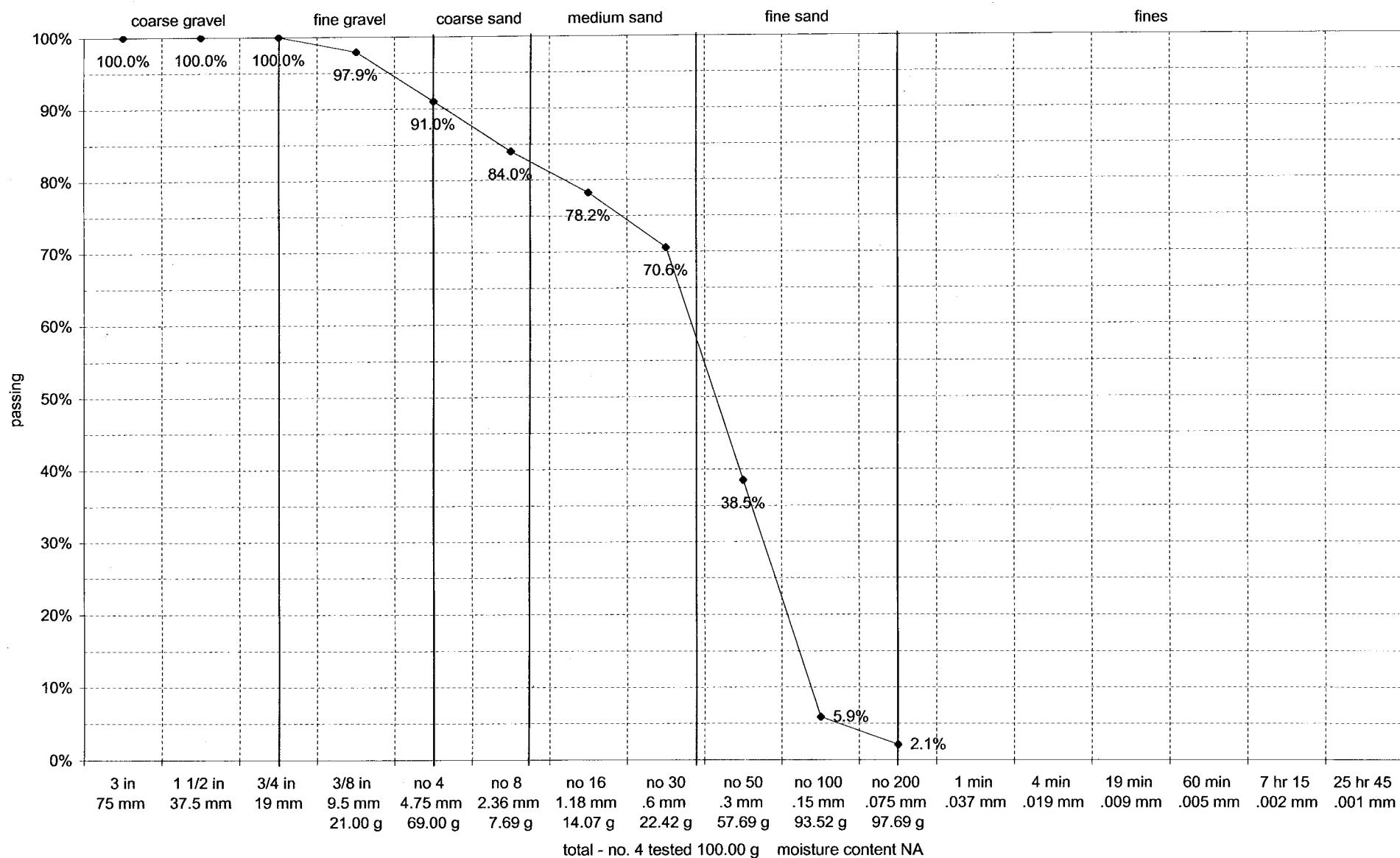


Coef. of uniformity NA Coef. of curvature NA D60: 0.110 mm D50: 0.100 mm D30: 0.0828 mm D10: NA

Gravel 0.0 % Sand 80.4 % Fines 19.6 %

38.0 - 40.5 ft Test Hole 2 Imperial National Wildlife Refuge 1-18-2006

total dry wt tested 1,000.00 g SP; Poorly graded sand. Total weights entered as constants for percentage replication.

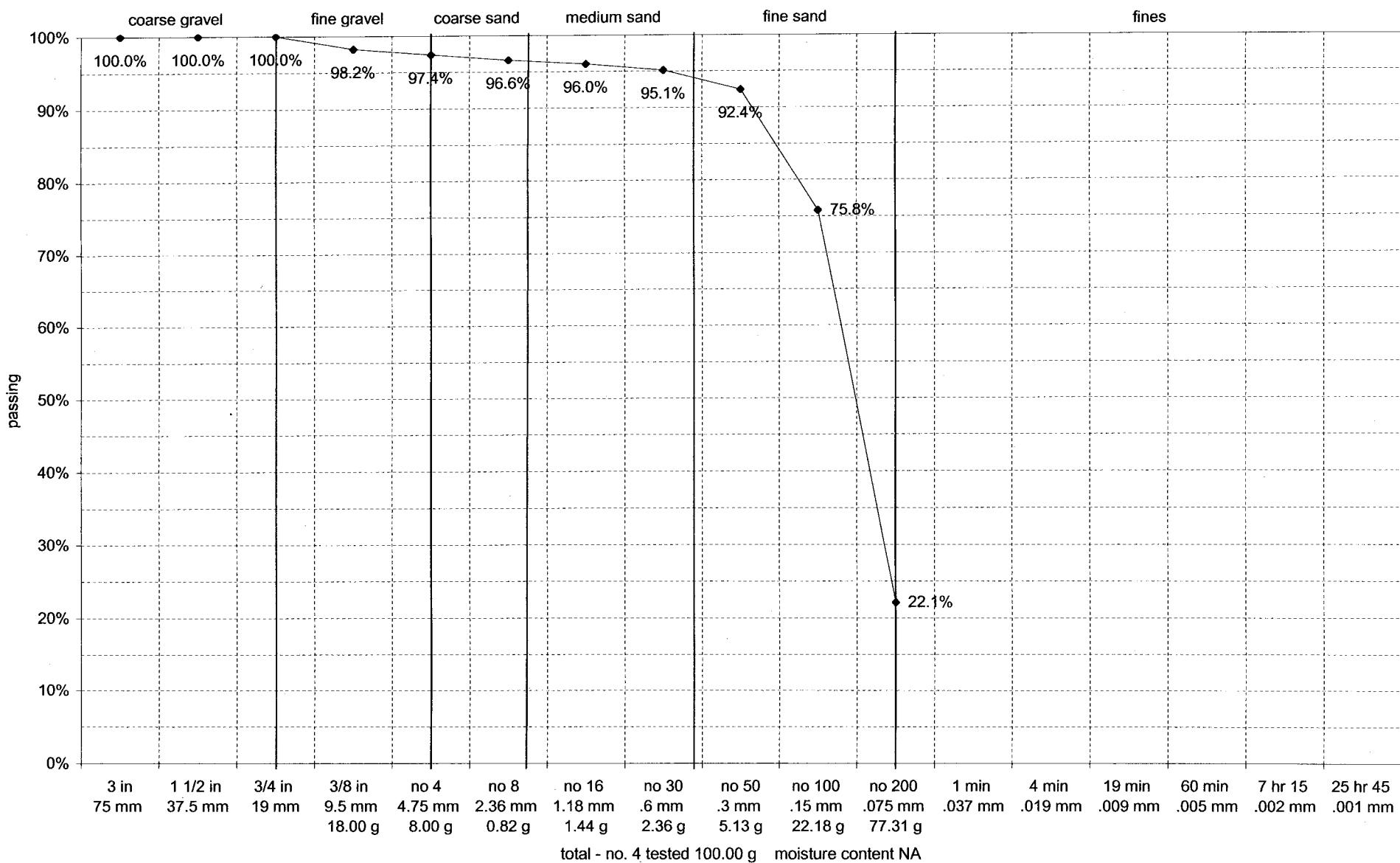


Coef. of uniformity 2.91 Coef. of curvature 0.80 D60: 0.477 mm D50: 0.385 mm D30: 0.250 mm D10: 0.164 mm

Gravel 9.0 % Sand 88.9 % Fines 2.1 %

0.0 - 3.0 ft Test Hole 4 Imperial National Wildlife Refuge 1-9-2006

total dry wt tested 1,000.00 g SM; Silty sand. Total weights entered as constants for percentage replication.

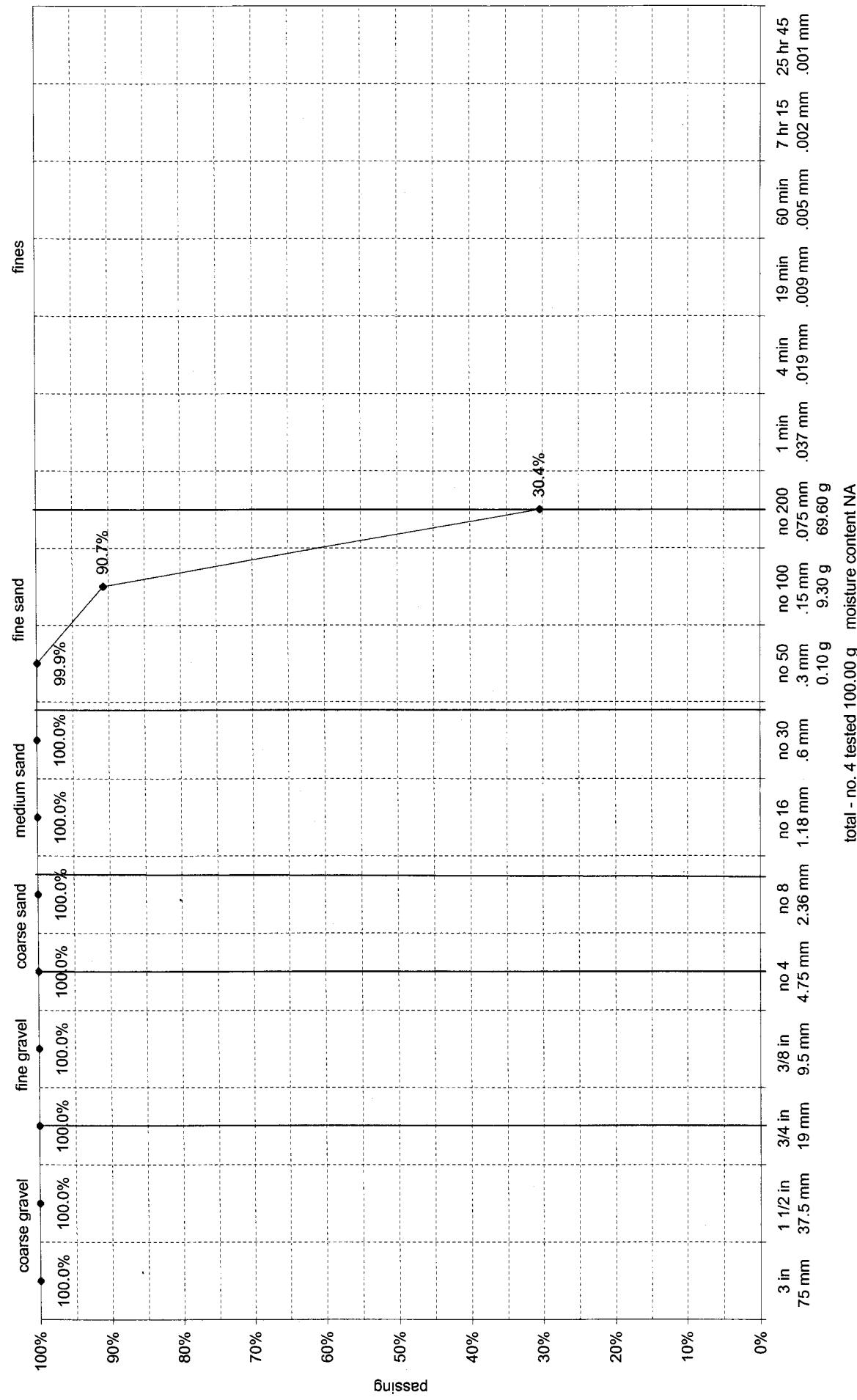


Coef. of uniformity NA Coef. of curvature NA D60: 0.122 mm D50: 0.108 mm D30: 0.0831 mm D10: NA

Gravel 2.6 % Sand 75.3 % Fines 22.1 %

3.0 - 5.0 ft Test Hole 4 Imperial National Wildlife Refuge 1-9-2006

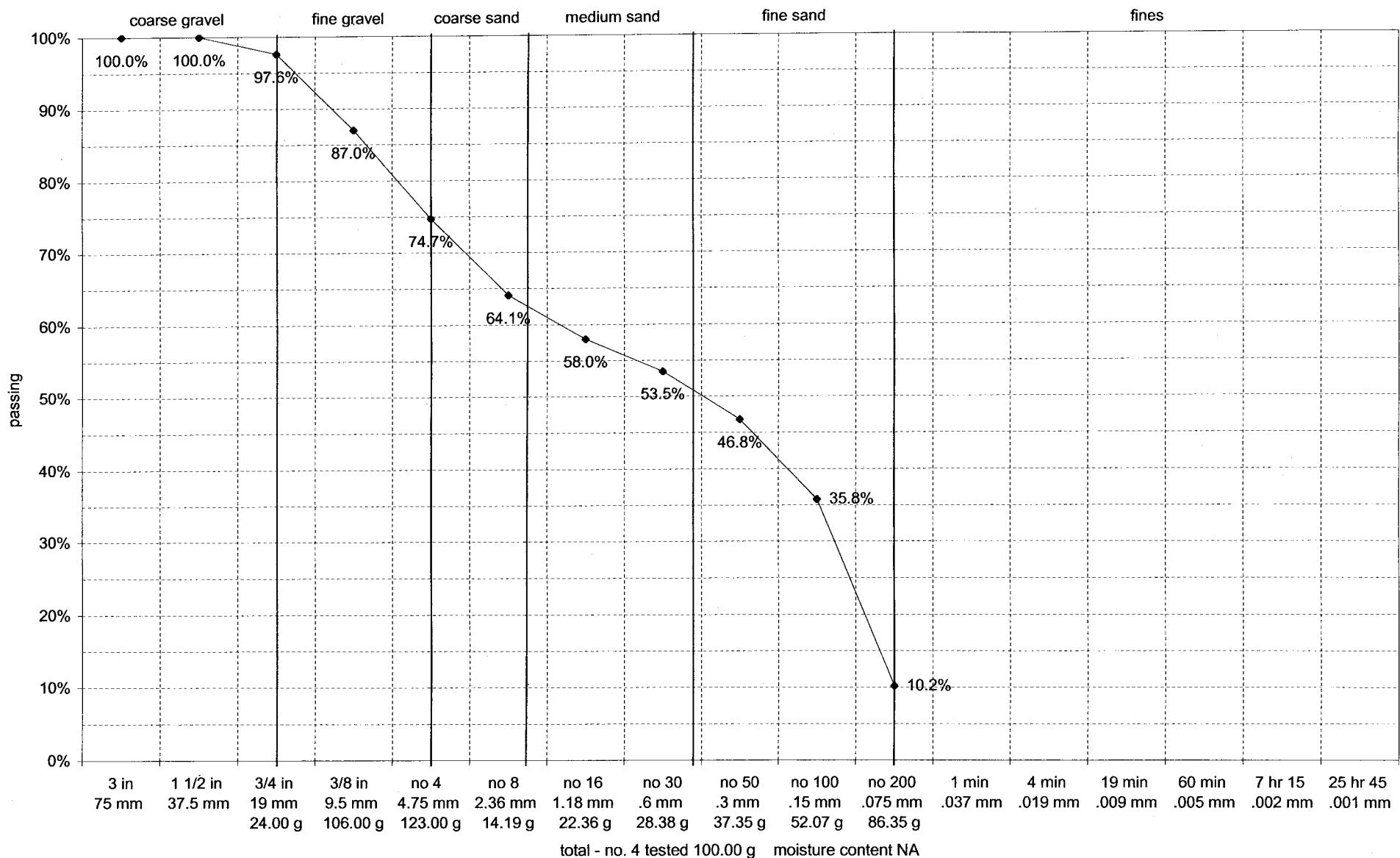
total dry wt tested 1,000.00 g SM; Silty sand. Total weights entered as constants for percentage replication.



Gravel 0.0 % Sand 69.6 % Fines 30.4 %
 Coef. of uniformity NA Coef. of curvature NA D60: 0.105 mm D50: 0.0940 mm D30: NA D10: NA
 3 in 1 1/2 in 3/4 in 1/2 in 1/4 in 1/8 in 1/16 in 1/32 in 1/64 in 1/128 in 1/512 in 1/1024 in

9.6 - 10.5 ft Test Hole 4 Imperial National Wildlife Refuge 1-9-2006

total dry wt tested 1,000.00 g SP-SM; Poorly graded sand with silt and gravel. Total weights entered as constants for percentage replication.

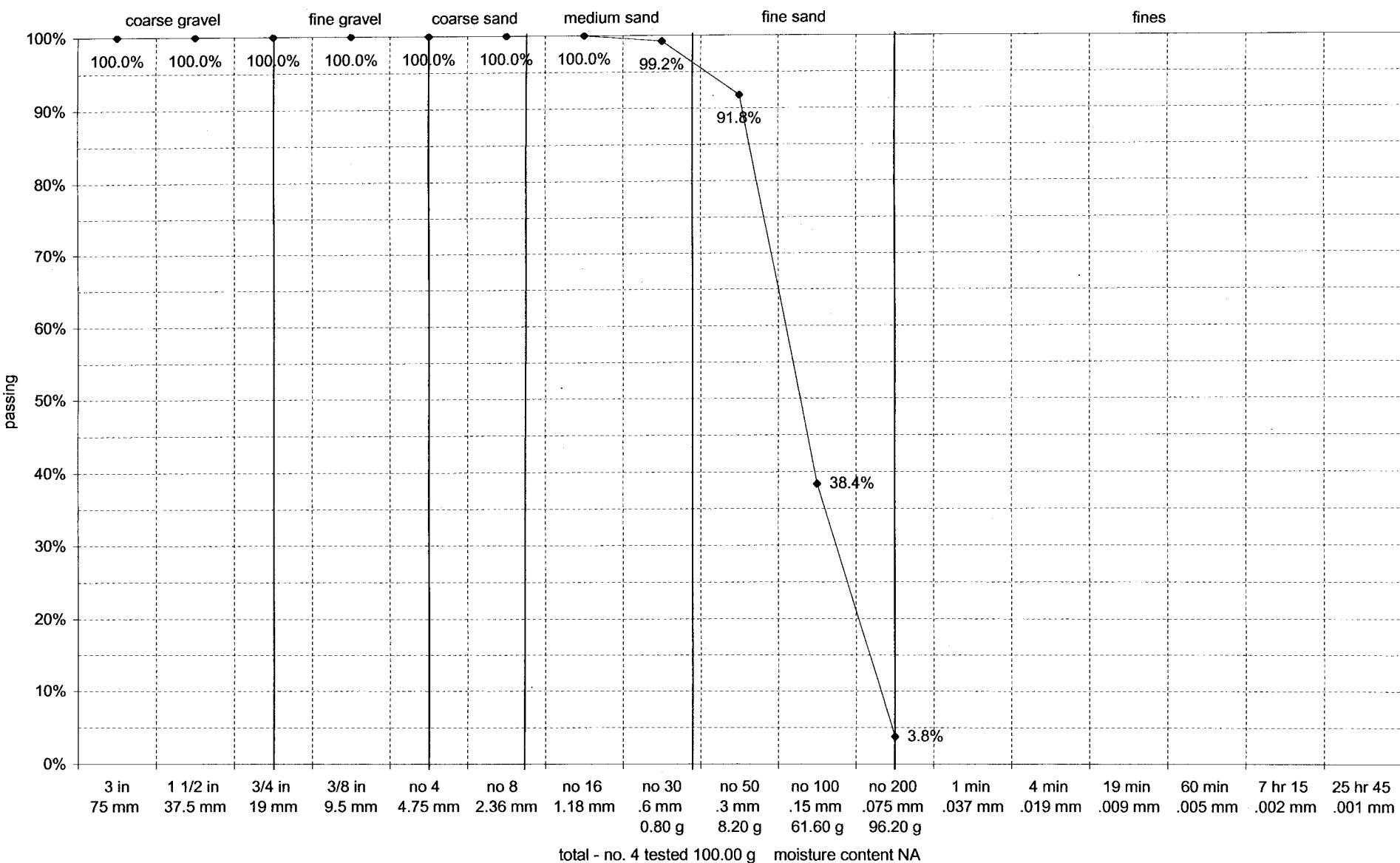


Coef. of uniformity NA Coef. of curvature NA D60: 1.48 mm D50: 0.418 mm D30: 0.128 mm D10: NA

Gravel 25.3 % Sand 64.5 % Fines 10.2 %

13.0 - 13.8 ft Test Hole 4 Imperial National Wildlife Refuge 1-9-2006

total dry wt tested 1,000.00 g SP; Poorly graded sand. Total weights entered as constants for percentage replication.

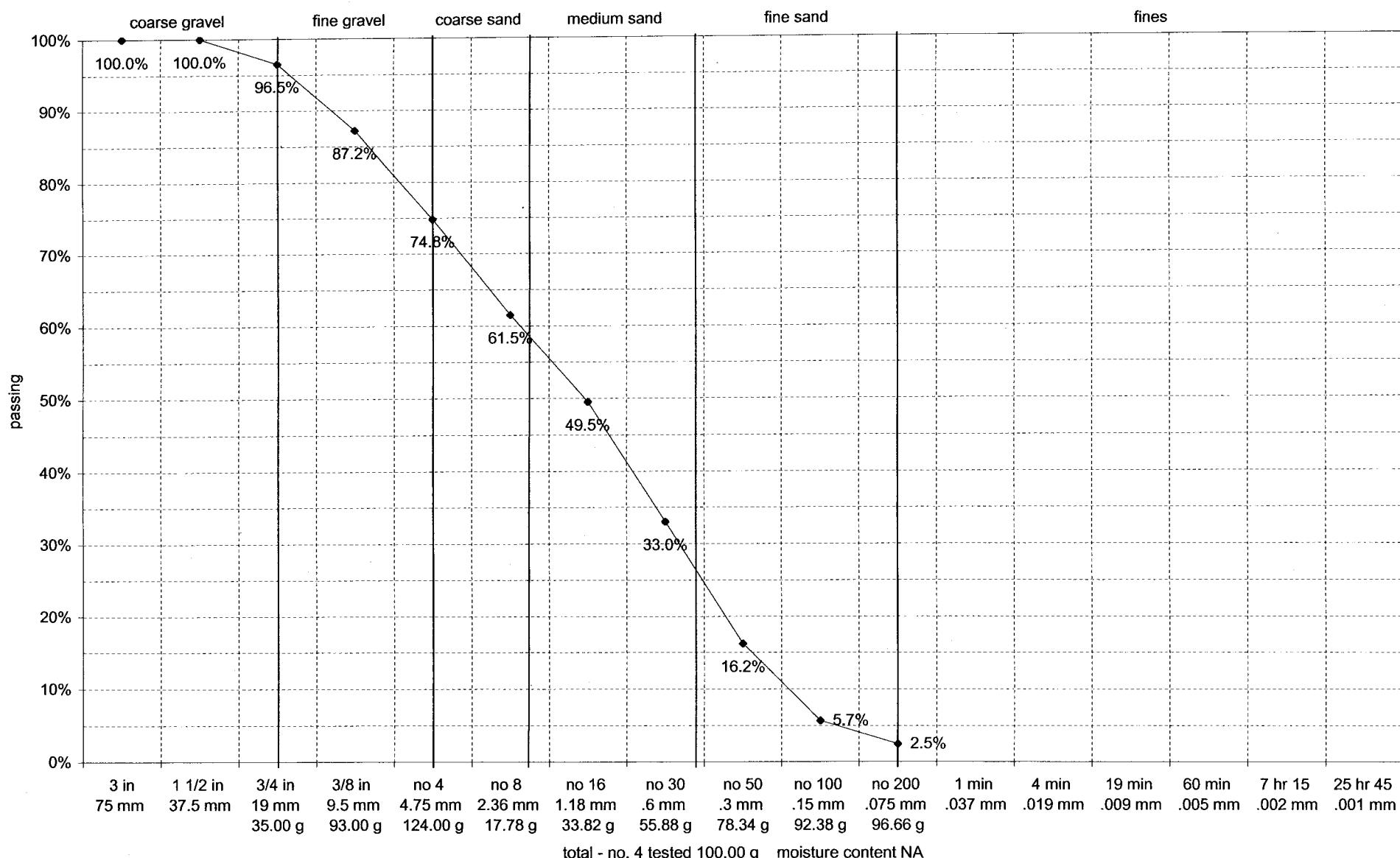


Coef. of uniformity 2.34 Coef. of curvature 0.95 D60: 0.199 mm D50: 0.174 mm D30: 0.127 mm D10: 0.0849 mm

Gravel 0.0 % Sand 96.2 % Fines 3.8 %

13.8 - 15.0 ft Test Hole 4 Imperial National Wildlife Refuge 1-9-2006

total dry wt tested 1,000.00 g SP; Poorly graded sand with gravel. Total weights entered as constants for percentage replication.

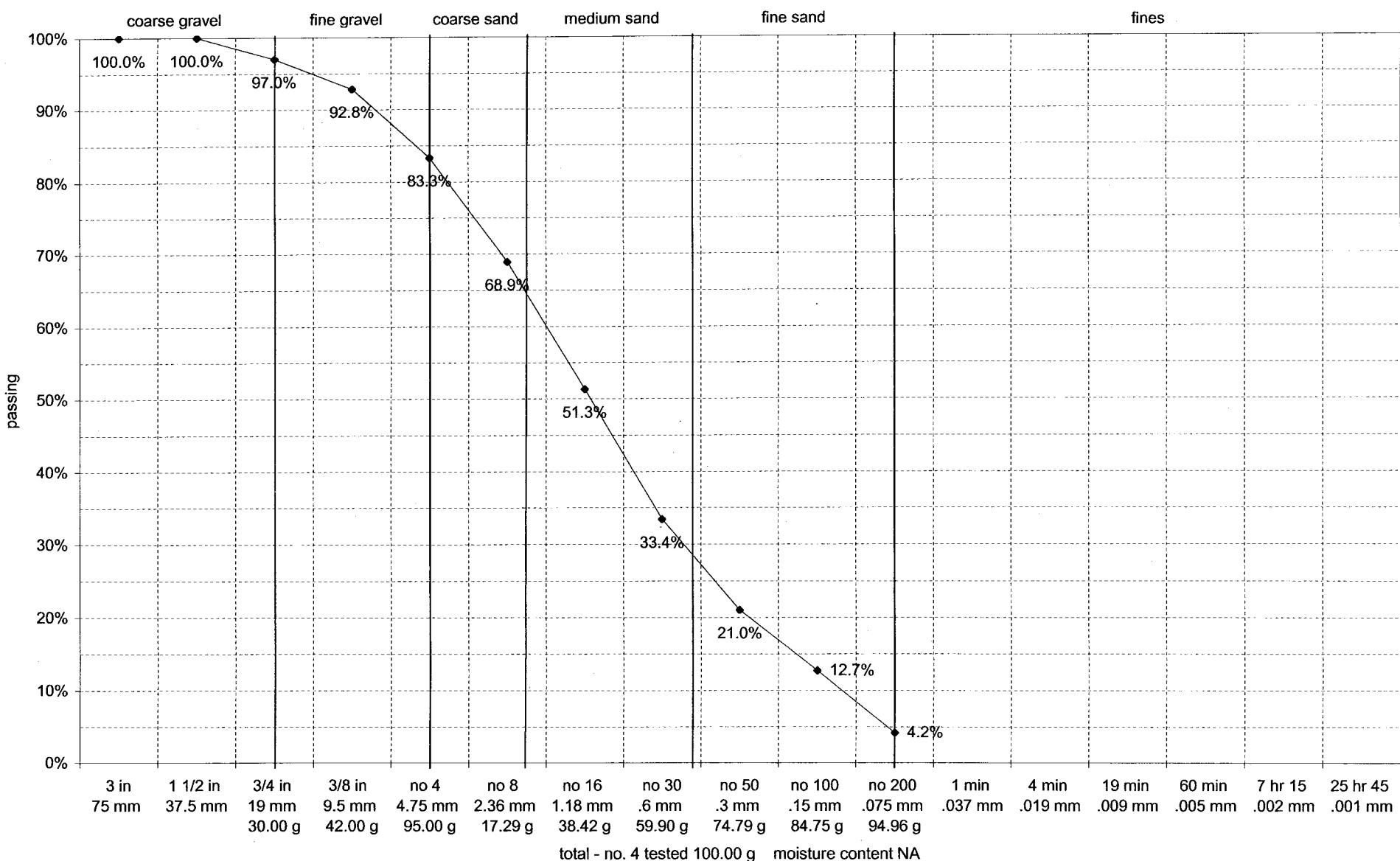


Coef. of uniformity 10.85 Coef. of curvature 0.65 D60: 2.16 mm D50: 1.21 mm D30: 0.530 mm D10: 0.199 mm

Gravel 25.2 % Sand 72.3 % Fines 2.5 %

18.0 - 19.1 ft Test Hole 4 Imperial National Wildlife Refuge 1-9-2006

total dry wt tested 1,000.00 g SW; Well-graded sand with gravel. Total weights entered as constants for percentage replication.



Coef. of uniformity 13.83

Coef. of curvature 1.24

D60: 1.66 mm

D50: 1.12 mm

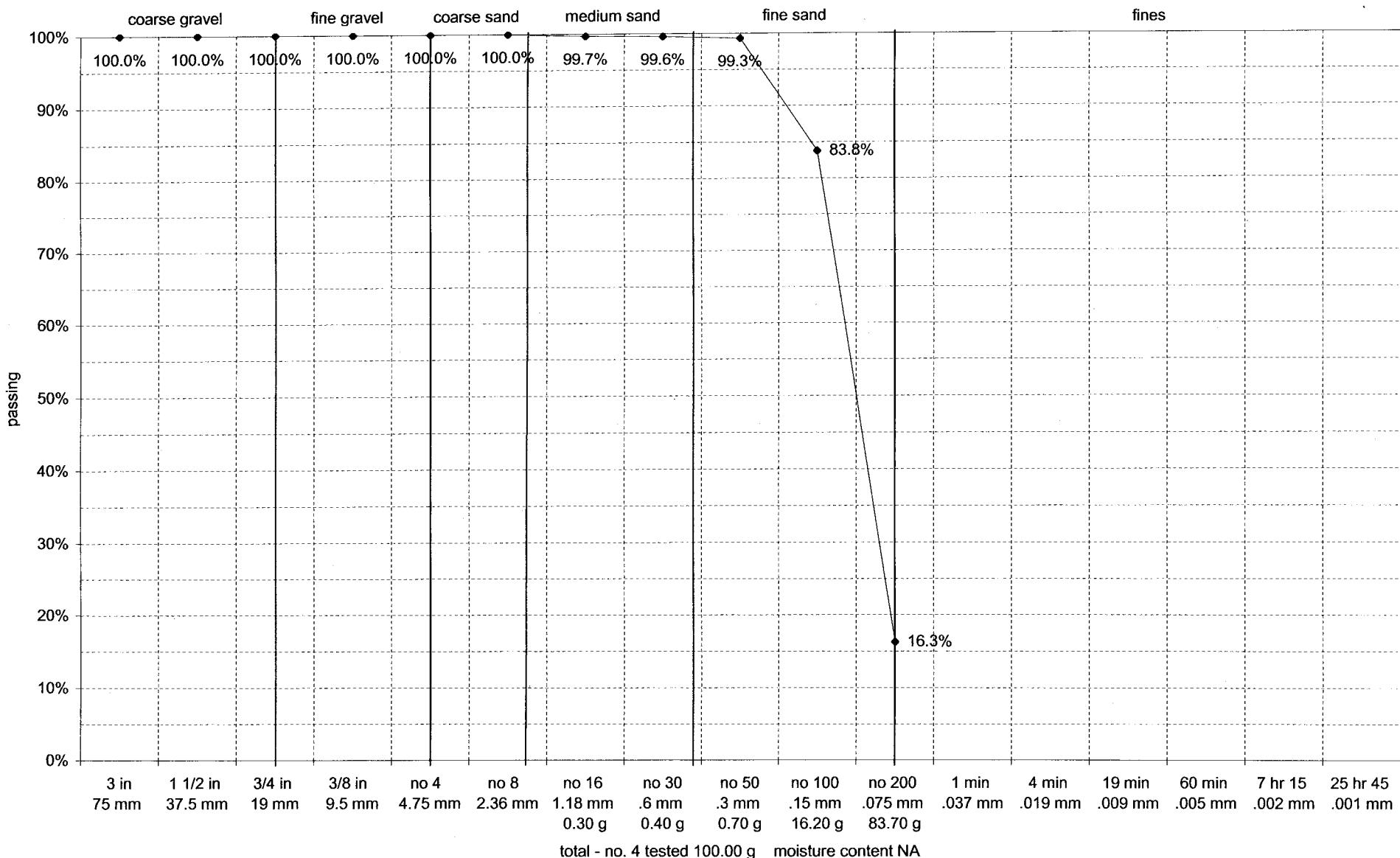
D30: 0.496 mm

D10: 0.120 mm

Gravel 16.7 % Sand 79.1 % Fines 4.2 %

8 ft Test Hole 5 Imperial National Wildlife Refuge 1-17-2006

total dry wt tested 1,000.00 g SM; Silty sand. "8 ft from auger flight" Total weights entered as constants for percentage replication.

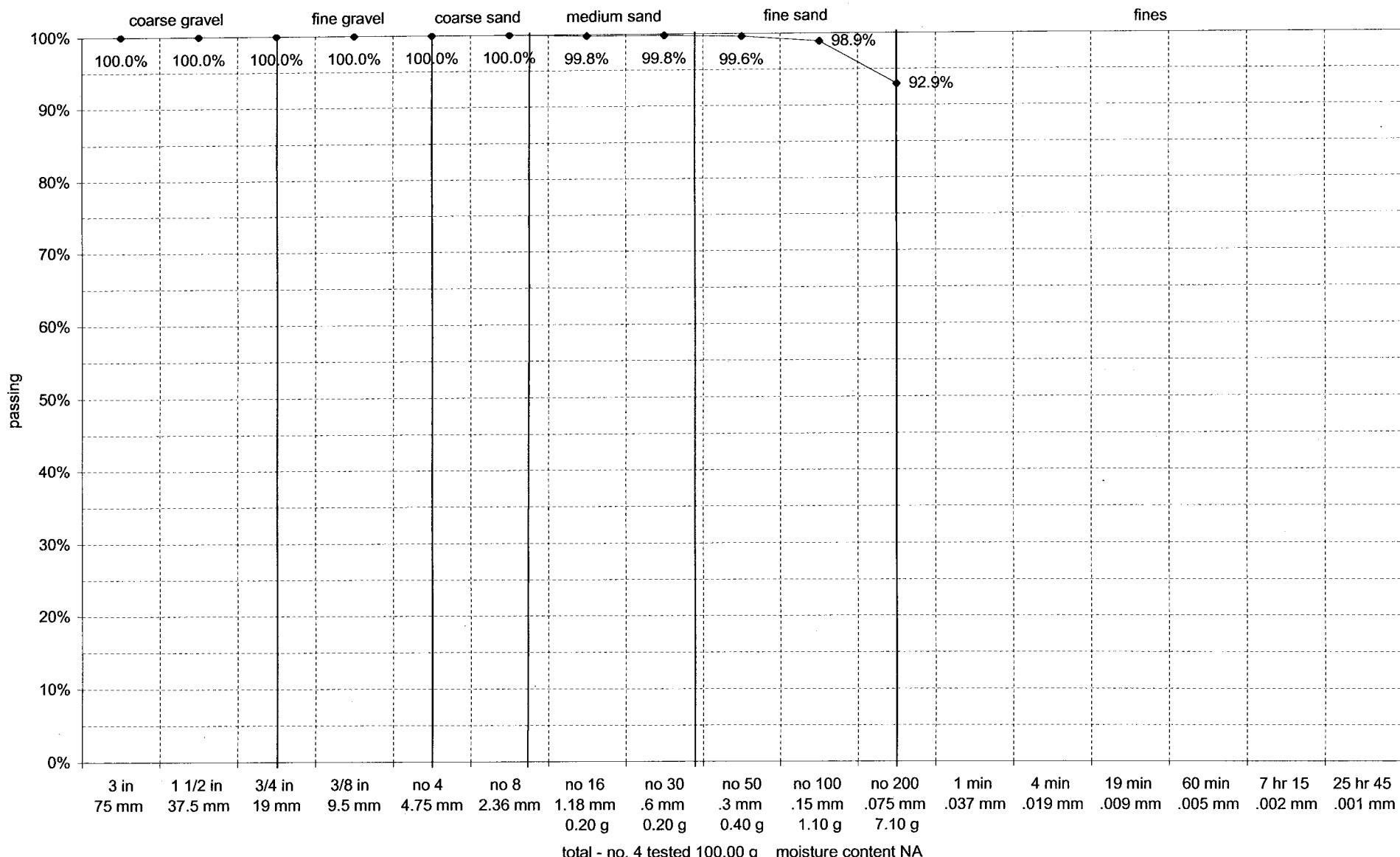


Coef. of uniformity NA Coef. of curvature NA D60: 0.117 mm D50: 0.106 mm D30: 0.0863 mm D10: NA

Gravel 0.0 % Sand 83.7 % Fines 16.3 %

18.5 - 20.5 ft Test Hole 5 Imperial National Wildlife Refuge 1-17-2006

total dry wt tested 1,000.00 g CL; Lean clay. Atterberg test: Liquid Limit = 46.0, Plasticity Index = 26.4. Total weights entered as constants for percentage replication.



Coef. of uniformity NA

Coef. of curvature NA

D60: NA

D50: NA

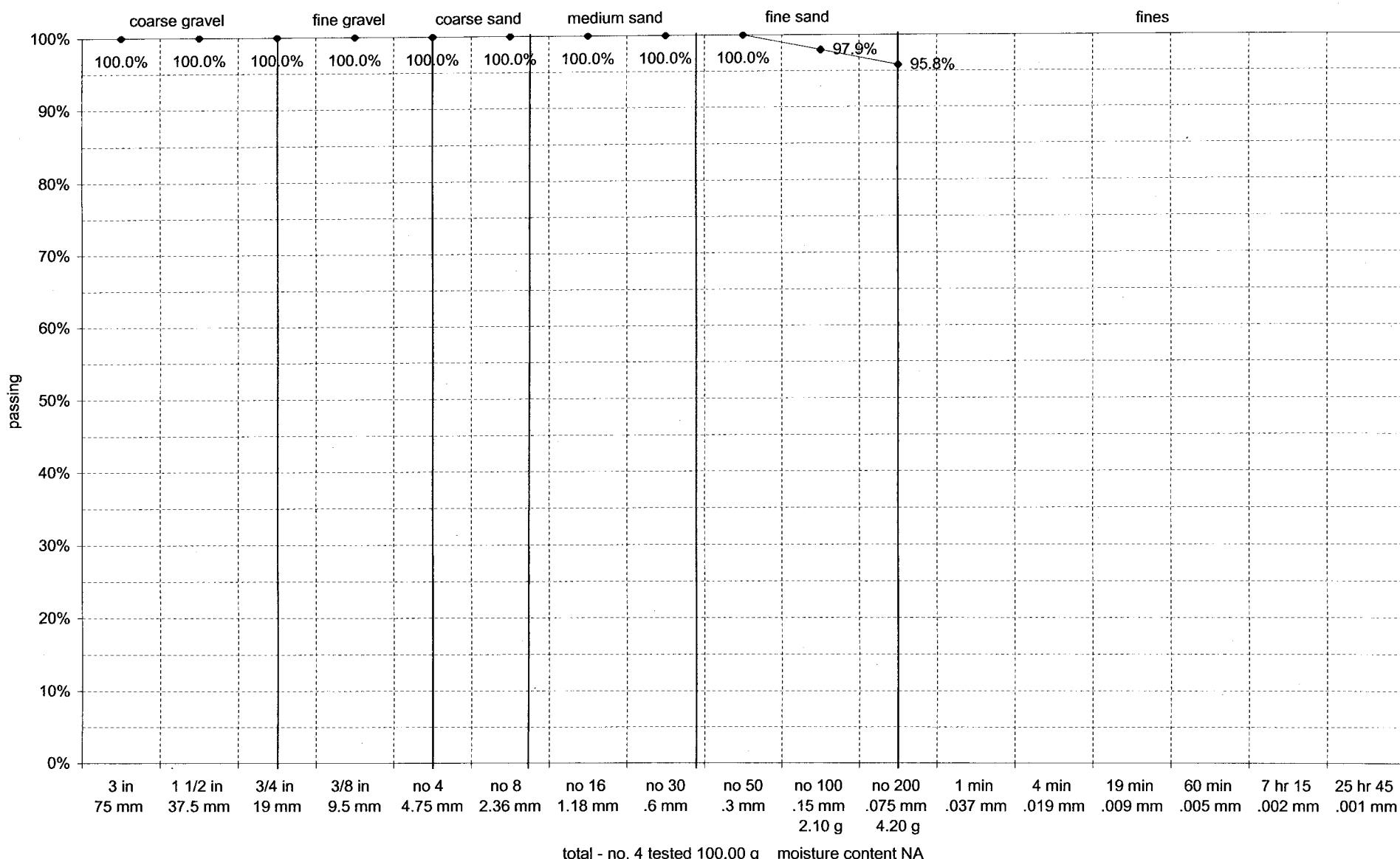
D30: NA

D10: NA

Gravel 0.0 % Sand 7.1 % Fines 92.9 %

28.0 - 28.5 ft Test Hole 5 Imperial National Wildlife Refuge 1-17-2006

total dry wt tested 1,000.00 g CH; Fat clay. Atterberg test: Liquid Limit = 53.8, Plasticity Index = 33.8. Total weights entered as constants for percentage replication.

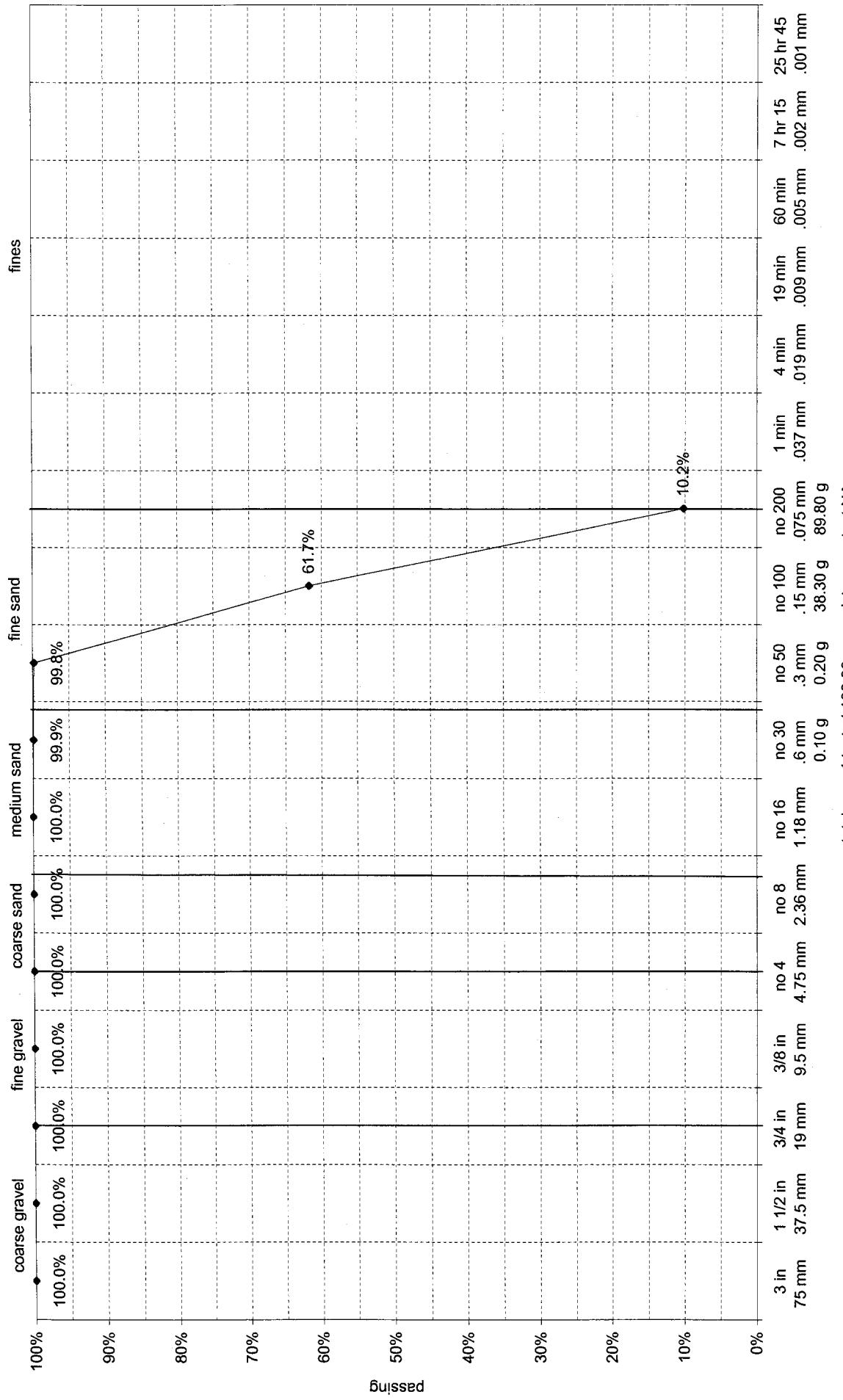


Coef. of uniformity NA Coef. of curvature NA D60: NA D50: NA D30: NA D10: NA

Gravel 0.0 % Sand 4.2 % Fines 95.8 %

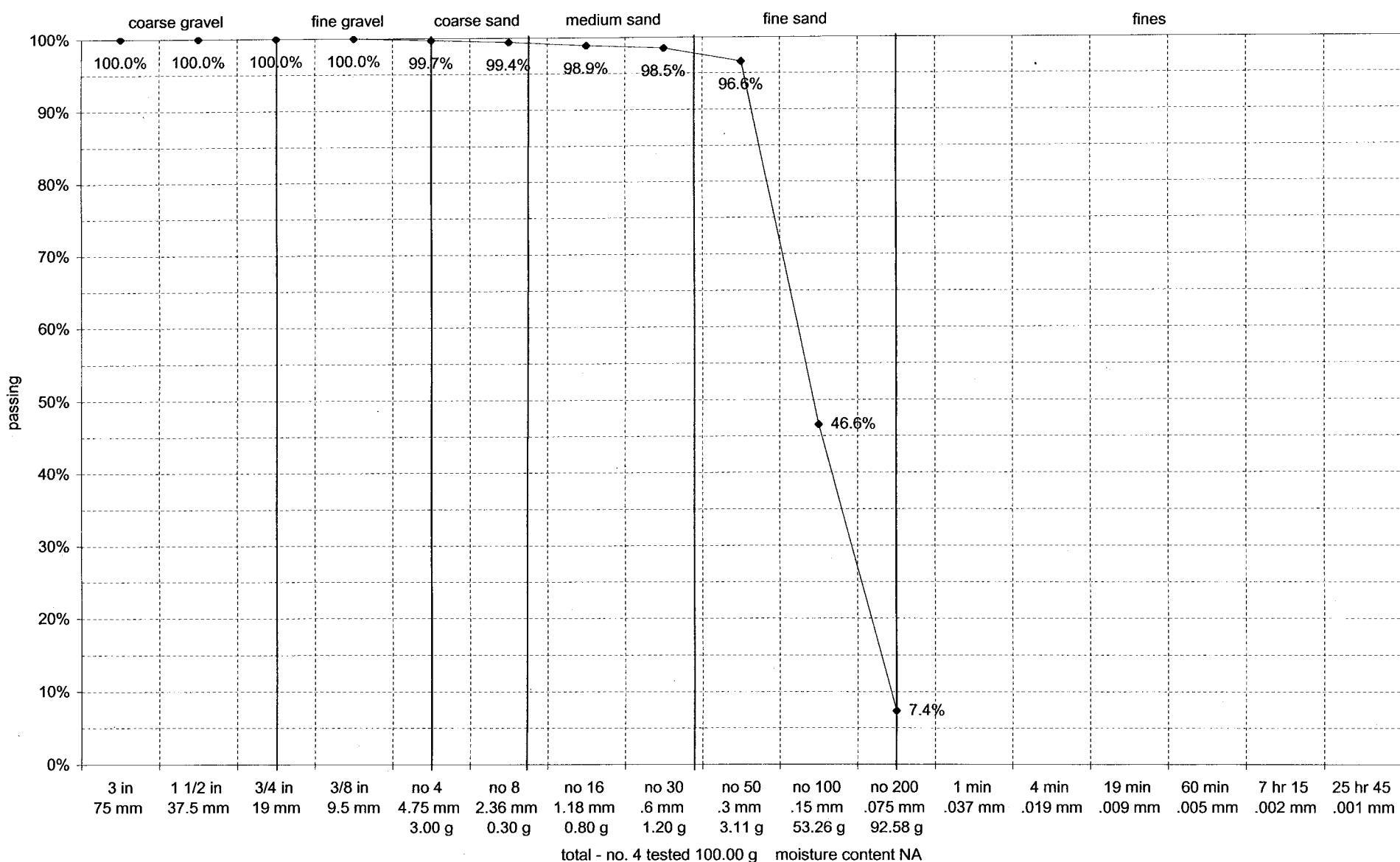
28.5 - 30.5 ft Test Hole 5 Imperial National Wildlife Refuge 1-17-2006

Total weights entered as constants for percentage replication.



38.5 - 40.5 ft Test Hole 5 Imperial National Wildlife Refuge 1-17-2006

total dry wt tested 1,000.00 g SP-SM; Poorly graded sand with silt. Total weights entered as constants for percentage replication.

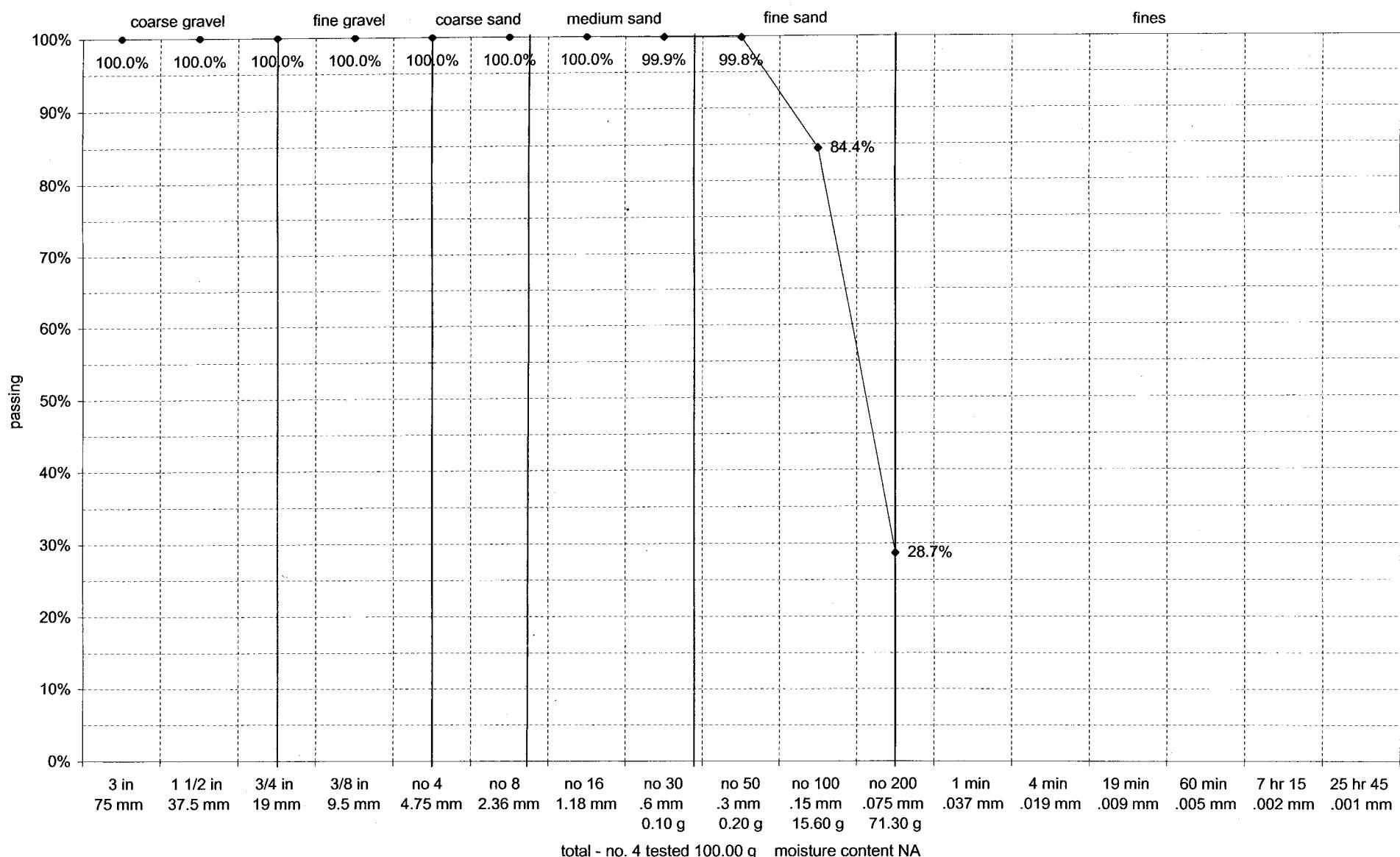


Coef. of uniformity 2.31 Coef. of curvature 0.88 D60: 0.181 mm D50: 0.157 mm D30: 0.112 mm D10: 0.0785 mm

Gravel 0.3 % Sand 92.3 % Fines 7.4 %

4.0 - 4.2 ft Test Hole 6 Imperial National Wildlife Refuge 12-28-2005

total dry wt tested 1,000.00 g SM; Silty sand. Total weights entered as constants for percentage replication.

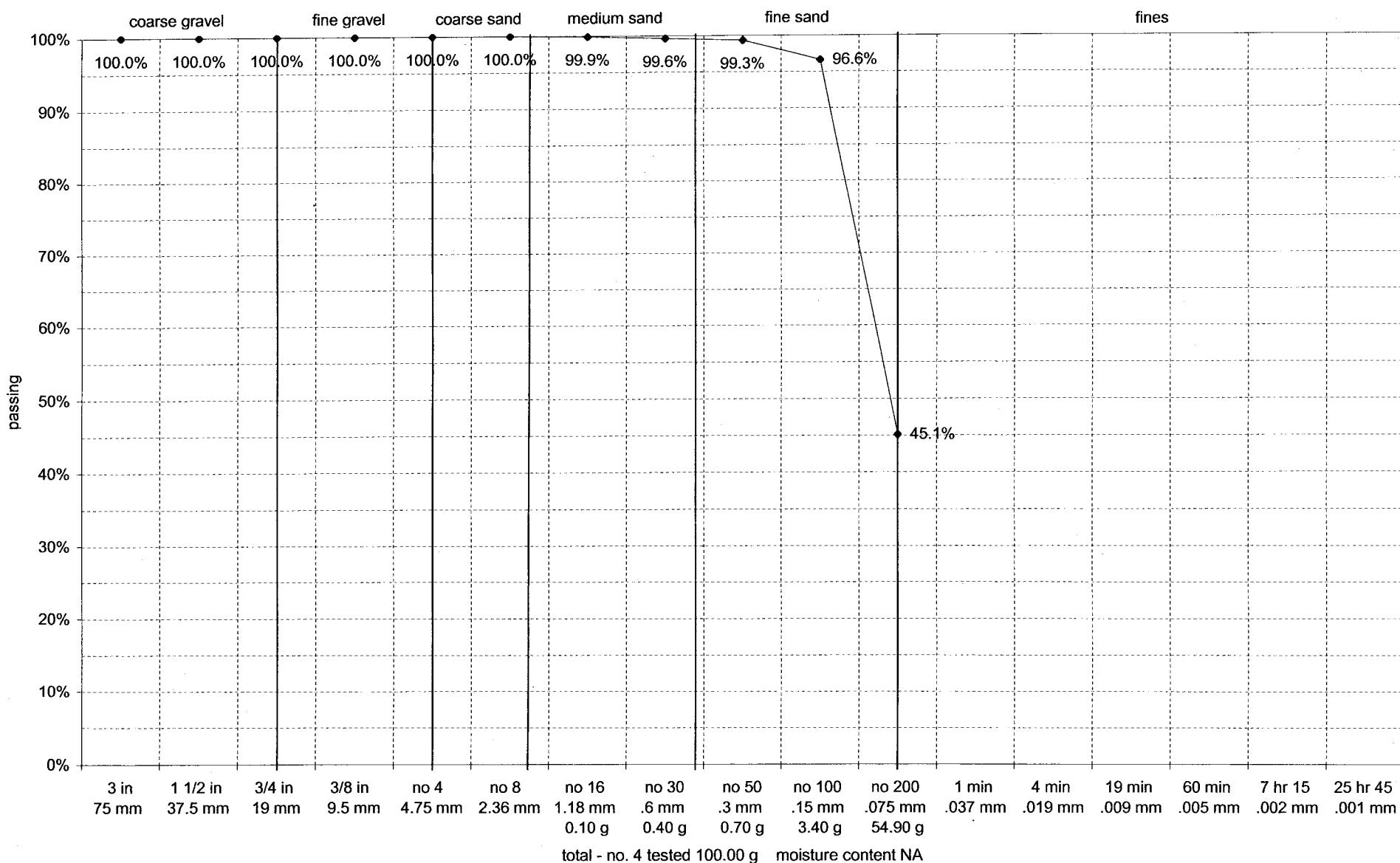


Coef. of uniformity NA Coef. of curvature NA D60: 0.111 mm D50: 0.0978 mm D30: 0.0762 mm D10: NA

Gravel 0.0 % Sand 71.3 % Fines 28.7 %

9.0 - 11.0 ft Test Hole 6 Imperial National Wildlife Refuge 12-28-2005

total dry wt tested 1,000.00 g SM; Silty sand. Total weights entered as constants for percentage replication.

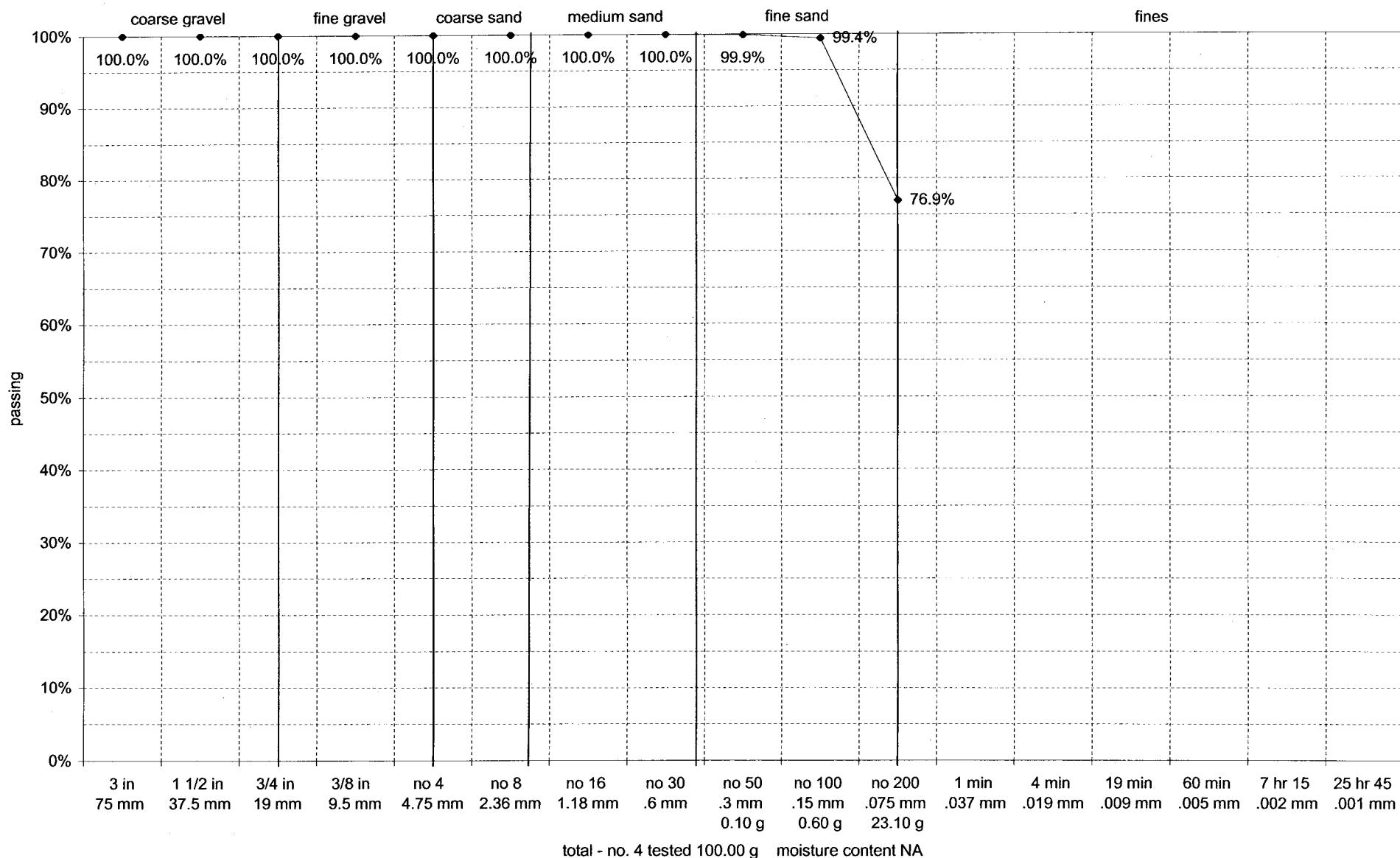


Coef. of uniformity NA Coef. of curvature NA D60: 0.0917 mm D50: 0.0801 mm D30: NA D10: NA

Gravel 0.0 % Sand 54.9 % Fines 45.1 %

14.0 - 16.0 ft Test Hole 6 Imperial National Wildlife Refuge 12-28-2005

total dry wt tested 1,000.00 g ML; Silt with sand. Total weights entered as constants for percentage replication.

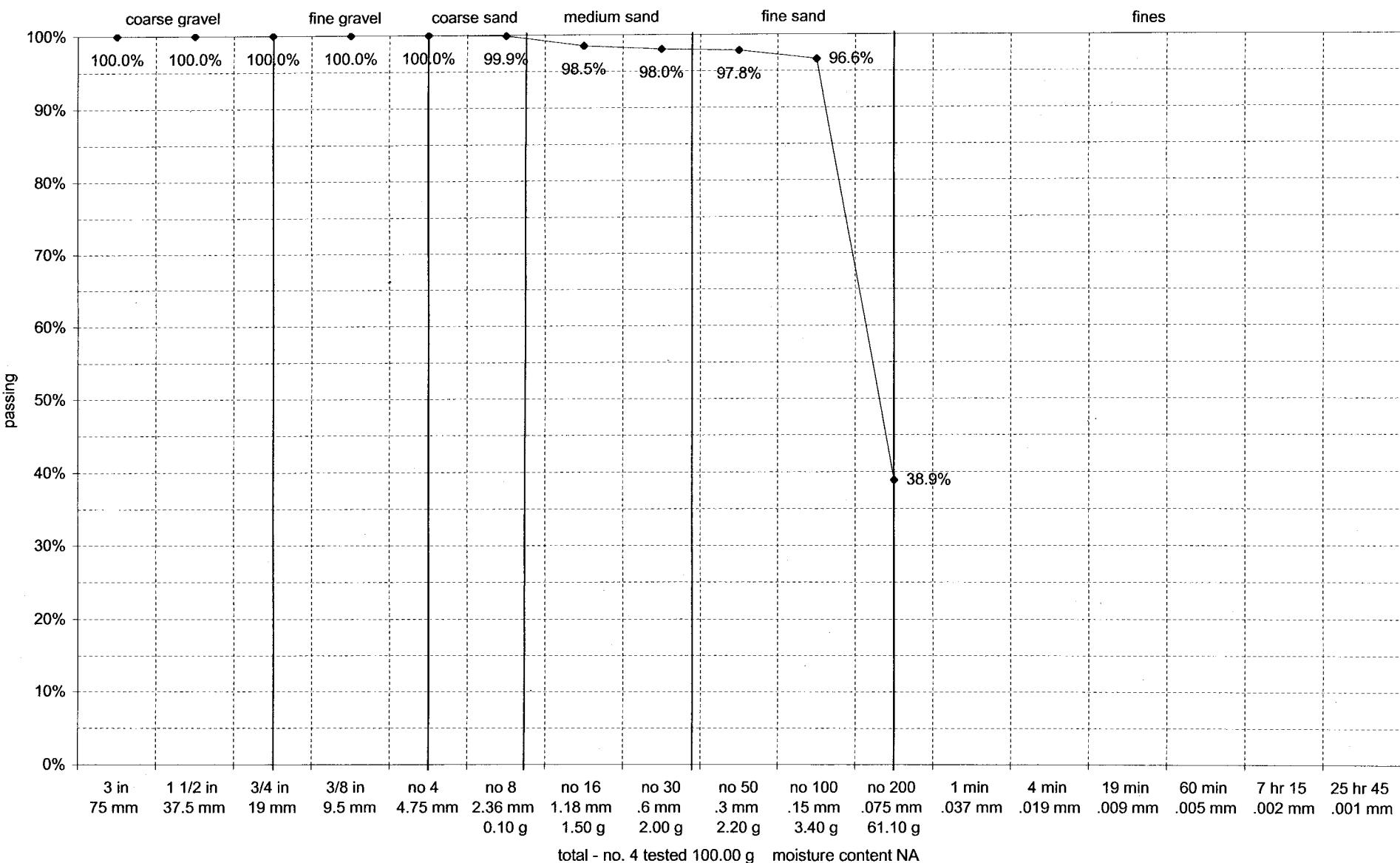


Coef. of uniformity NA Coef. of curvature NA D60: NA D50: NA D30: NA D10: NA

Gravel 0.0 % Sand 23.1 % Fines 76.9 %

19.0 - 21.0 ft Test Hole 6 Imperial National Wildlife Refuge 12-29-2005

total dry wt tested 1,000.00 g SM; Silty sand. Total weights entered as constants for percentage replication.



Coef. of uniformity NA Coef. of curvature NA D60: 0.0966 mm D50: 0.0857 mm D30: NA D10: NA

Gravel 0.0 % Sand 61.1 % Fines 38.9 %

APPENDIX III
WATER ANALYSES



YUMA DESALTING PLANT LABORATORY CHEMICAL ANALYSIS OF WATER SAMPLES

MISC. WELL INWR TH-1, 76 gpm

USGS STATION NUMBER: MISC_WELL

SITE CODE: W0990

LAB NUMBER: 21399

SAMPLED BY: FCROXEN

DATE COLLECTED: 12/27/2005

TIME COLLECTED: 12:00

ELECTROCONDUCTIVITY / EC (in microsiemens / cm): 1010 (est)

FIELD TEMP (C): 22.2

TDS - BY EVAPORATION AT 180 DEGREES C (in mg/L): 624

SALT CONDUCTIVITY: 0.9362

TDS - BY SUMMATION WITH HCO3 CORRECTION (HCO3 / 2.03) (in mg/L): 646 pH: 8.02

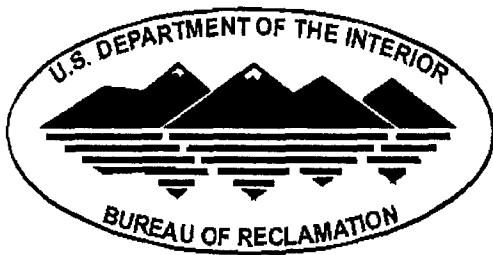
All values in mg/L

SODIUM (Na):	106.00	SILICA (SiO2):	18.00
POTASSIUM (K):	4.88	BORON (B):	<0.20
CALCIUM (Ca):	75.10	FLUORIDE (F):	0.41
MAGNESIUM (Mg):	25.60	AMMONIA (NH4 - N):	1.00
CARBONATE (CO3):	0.00	PHOSPHATE (PO4 - P):	<0.20
BICARBONATE (HCO3):	281.00	IRON (Fe):	<0.20
CHLORIDE (Cl):	90.70	MANGANESE (Mn):	0.225
SULFUR as Sulfate (SO4):	187.00	BARIUM (Ba):	0.190
NITRATE (NO3 - N):	<0.20	STRONTIUM (Sr):	1.06

Cations, mE / L: 10.60

Anions, mE / L: 11.10

% DIFFERENCE: -2.44



YUMA DESALTING PLANT LABORATORY CHEMICAL ANALYSIS OF WATER SAMPLES

MISC. WELL INWR North Well

USGS STATION NUMBER: MISC_WELL

SITE CODE: W0990

LAB NUMBER: 21388

SAMPLED BY: FCROXEN

DATE COLLECTED: 12/22/2005

TIME COLLECTED: 13:01

ELECTROCONDUCTIVITY / EC (in microsiemens / cm): 1210

FIELD TEMP (C): 21.6

TDS - BY EVAPORATION AT 180 DEGREES C (in mg/L): 832

SALT CONDUCTIVITY: 0.6488

TDS - BY SUMMATION WITH HCO₃ CORRECTION (HCO₃ / 2.03) (in mg/L): 785

pH: 7.91

All values in mg/L

SODIUM (Na):	133.00	SILICA (SiO ₂):	24.80
POTASSIUM (K):	5.82	BORON (B):	<0.25
CALCIUM (Ca):	97.60	FLUORIDE (F):	0.49
MAGNESIUM (Mg):	23.60	AMMONIA (NH ₄ - N):	<0.050
CARBONATE (CO ₃):	0.00	PHOSPHATE (PO ₄ - P):	<0.25
BICARBONATE (HCO ₃):	192.00	IRON (Fe):	0.86
CHLORIDE (Cl):	116.00	MANGANESE (Mn):	0.12
SULFUR as Sulfate (SO ₄):	289.00	BARIUM (Ba):	0.0838
NITRATE (NO ₃ - N):	<0.25	STRONTIUM (Sr):	1.14

Cations, mE / L: 12.80

Anions, mE / L: 12.50

% DIFFERENCE: 1.06



YUMA DESALTING PLANT LABORATORY CHEMICAL ANALYSIS OF WATER SAMPLES

MISC. WELL INWR TH-2 Shallow Well - 40ft.

USGS STATION NUMBER: MISC_WELL

SITE CODE: W0990

LAB NUMBER: 21686

SAMPLED BY: T Fox

DATE COLLECTED: 1/24/2006

TIME COLLECTED: :

ELECTROCONDUCTIVITY / EC (in microsiemens / cm): 1270

FIELD TEMP (C): 22.8

TDS - BY EVAPORATION AT 180 DEGREES C (in mg/L): 796

SALT CONDUCTIVITY: 0.6008

TDS - BY SUMMATION WITH HCO₃ CORRECTION (HCO₃ / 2.03) (in mg/L): 763

pH: 8.01

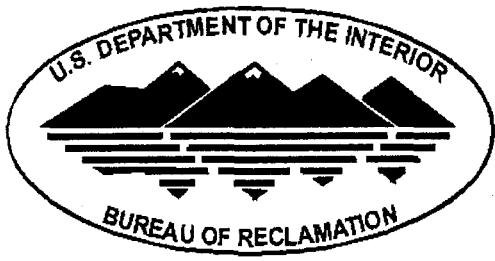
All values in mg/L

SODIUM (Na):	123.00	SILICA (SiO ₂):	24.00
POTASSIUM (K):	5.12	BORON (B):	<0.25
CALCIUM (Ca):	88.50	FLUORIDE (F):	0.47
MAGNESIUM (Mg):	25.70	AMMONIA (NH ₄ - N):	0.297
CARBONATE (CO ₃):	0.00	PHOSPHATE (PO ₄ - P):	<0.25
BICARBONATE (HCO ₃):	245.00	IRON (Fe):	<0.25
CHLORIDE (Cl):	107.00	MANGANESE (Mn):	0.33
SULFUR as Sulfate (SO ₄):	268.00	BARIUM (Ba):	0.0957
NITRATE (NO ₃ - N):	<0.25	STRONTIUM (Sr):	0.98

Cations, mE / L: 12.00

Anions, mE / L: 12.70

% DIFFERENCE: -2.62



YUMA DESALTING PLANT LABORATORY CHEMICAL ANALYSIS OF WATER SAMPLES

MISC. WELL INWR South Well

USGS STATION NUMBER: MISC_WELL	SITE CODE: W0990
LAB NUMBER: 21425	SAMPLED BY: FCROXEN
DATE COLLECTED: 12/29/2005	TIME COLLECTED: 15:17
ELECTROCONDUCTIVITY / EC (in microsiemens / cm): 1170	FIELD TEMP (C): 21.6
TDS - BY EVAPORATION AT 180 DEGREES C (in mg/L): 748	SALT CONDUCTIVITY: 0.588
TDS - BY SUMMATION WITH HCO3 CORRECTION (HCO3 / 2.03) (in mg/L): 688	pH: 8.01

All values in mg/L

SODIUM (Na):	99.00	SILICA (SiO2):	21.40
POTASSIUM (K):	4.36	BORON (B):	<0.25
CALCIUM (Ca):	89.80	FLUORIDE (F):	0.51
MAGNESIUM (Mg):	19.00	AMMONIA (NH4 - N):	<0.050
CARBONATE (CO3):	0.00	PHOSPHATE (PO4 - P):	<0.25
BICARBONATE (HCO3):	220.00	IRON (Fe):	<0.25
CHLORIDE (Cl):	98.10	MANGANESE (Mn):	0.21
SULFUR as Sulfate (SO4):	248.00	BARIUM (Ba):	0.0690
NITRATE (NO3 - N):	<0.25	STRONTIUM (Sr):	0.99

Cations, mE / L: 10.50

Anions, mE / L: 11.60

% DIFFERENCE: -5.07



YUMA DESALTING PLANT LABORATORY CHEMICAL ANALYSIS OF WATER SAMPLES

MISC. WELL INWR TH-4

USGS STATION NUMBER: MISC_WELL

SITE CODE: W0990

LAB NUMBER: 21652

SAMPLED BY: T Fox

DATE COLLECTED: 1/17/2006

TIME COLLECTED: 10:37

ELECTROCONDUCTIVITY / EC (in microsiemens / cm): 2120

FIELD TEMP (C): 22.5

TDS - BY EVAPORATION AT 180 DEGREES C (in mg/L): 1350

SALT CONDUCTIVITY: 0.6085

TDS - BY SUMMATION WITH HCO₃ CORRECTION (HCO₃ / 2.03) (in mg/L): 1290

pH: 7.5

All values in mg/L

SODIUM (Na):	281.00	SILICA (SiO ₂):	26.60
POTASSIUM (K):	5.5	BORON (B):	<0.50
CALCIUM (Ca):	91.20	FLUORIDE (F):	2.24
MAGNESIUM (Mg):	33.00	AMMONIA (NH ₄ - N):	0.197
CARBONATE (CO ₃):	0.00	PHOSPHATE (PO ₄ - P):	<0.50
BICARBONATE (HCO ₃):	367.00	IRON (Fe):	<0.50
CHLORIDE (Cl):	232.00	MANGANESE (Mn):	1.31
SULFUR as Sulfate (SO ₄):	439.00	BARIUM (Ba):	0.0357
NITRATE (NO ₃ - N):	<0.50	STRONTIUM (Sr):	1.37

Cations, mE / L: 19.60

Anions, mE / L: 21.80

% DIFFERENCE: -5.29



YUMA DESALTING PLANT LABORATORY CHEMICAL ANALYSIS OF WATER SAMPLES

INWR Martinez Lake Inlet.

USGS STATION NUMBER:	SITE CODE: W0990		
LAB NUMBER:	21424	SAMPLED BY:	FCROXEN
DATE COLLECTED:	12/29/2005	TIME COLLECTED:	12:35
ELECTROCONDUCTIVITY / EC (in microsiemens / cm):	1280	FIELD TEMP (C):	13.1
TDS - BY EVAPORATION AT 180 DEGREES C (in mg/L):	780	SALT CONDUCTIVITY:	0.5781
TDS - BY SUMMATION WITH HCO ₃ CORRECTION (HCO ₃ / 2.03) (in mg/L):	740	pH:	8.31

All values in mg/L

SODIUM (Na):	114.00	SILICA (SiO ₂):	7.11
POTASSIUM (K):	4.80	BORON (B):	<0.25
CALCIUM (Ca):	79.10	FLUORIDE (F):	0.44
MAGNESIUM (Mg):	29.60	AMMONIA (NH ₄ - N):	<0.050
CARBONATE (CO ₃):	1.21	PHOSPHATE (PO ₄ - P):	<0.25
BICARBONATE (HCO ₃):	188.00	IRON (Fe):	<0.25
CHLORIDE (Cl):	118.00	MANGANESE (Mn):	<0.10
SULFUR as Sulfate (SO ₄):	291.00	BARIUM (Ba):	0.120
NITRATE (NO ₃ - N):	0.46	STRONTIUM (Sr):	1.17

Cations, mE / L: 11.50

Anions, mE / L: 12.60

% DIFFERENCE: -4.73

APPENDIX IV
PUMP TEST DATA

Analysis of INWR WELL #1 during Step Drawdown Test of INWR WELL #2 of December 29, 2006 Thursday

Time MST	t, min	t', min	$\log_{10}(t/t')$	Residual Drawdown. s', feet	Depth to Water DW, feet	TH-1 DW, feet	TH-1 Drawdown feet	
11:45					7.36	6.07	0	STATIC
11:49								PUMP ON at 1100 gpm
13:25				9.67				
13:30	0							START MAXIMUM Q AT 1570 GPM
13:38	8			10.37				
13:50	20					6.32	0.25	
13:59	29				10.49			
14:31	61				10.56			
14:43	73					6.39	0.32	
15:10	100				10.56?			
15:26	116				10.61			
15:34	124						6.43	0.36
15:45	135							PUMP OFF. START RECOVERY OF INWR #1 (NORTH WELL)
135.01	0							
135.5	0.5	2.433		2.08	9.44			
136	1							Plot of $\log_{10}(t/t')$ vs. residual drawdown (s') gives
137	2	1.836		1.6	8.96			a Transmissivity of 400,000 gpd/ft
138	3				8.74			
139	4				8.64			Storage coefficient = $.3*T*t_0/r^2 = .088$
140	5	1.447		1.18	8.54			where $t_0 = 2 \text{ min} = 0.001386 \text{ days}$
141	6	1.371		1.09	8.45			T = 400464 gpd/ft
142	7	1.307		1.04	8.4			r = 43.5 feet (distance between INWR#1 and INWR#2)
143	8	1.252		0.99	8.35			
144	9	1.204		0.93	8.29			
145	10	1.161		0.86	8.22			
147	12	1.088		0.81	8.17			
150	15	1		0.73	8.09			
155	20	0.889		0.61	7.97			
160	25	0.806		0.53	7.89			
165	30	0.74		0.45	7.81			
173	38					6.33	0.26	
176	41	0.633		0.37	7.73			

Imperial National Wildlife Refuge Step Drawdown Test of INWR WELL #2 (South Well)

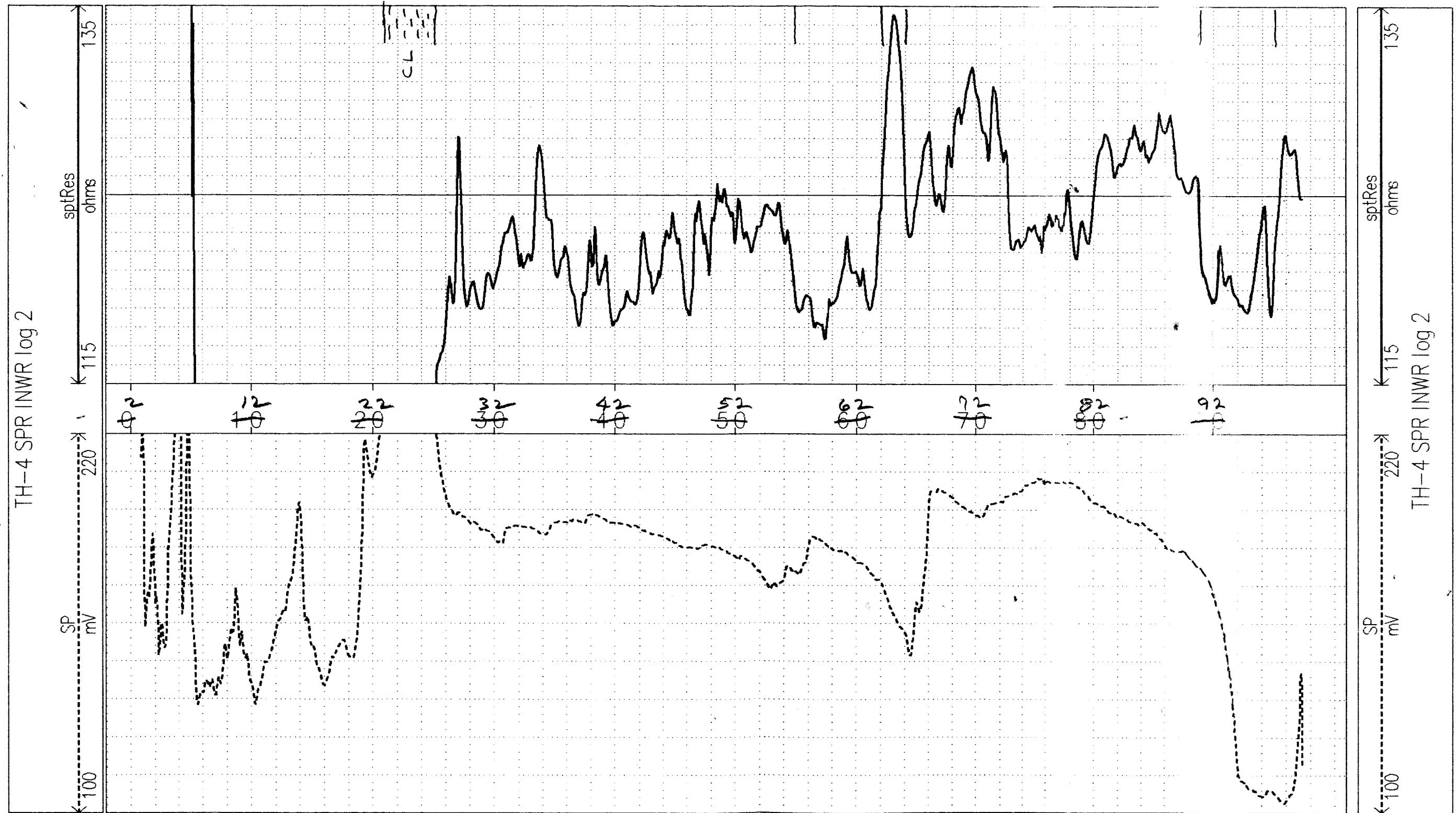
December 29, 2005 Thursday

INWR #2 is 43.5 feet south of INWR #1

Time (MST)	t (min)	Q (gpm)	$\log_{10}(t/t')$	INWR #2		INWR #2		INWR #2		INWR #1		TH-1	REMARKS
				Pumping Level PL, feet	Drawdown s, feet	Residual drawdown (PL-static) s', feet	Calculated residual drawdown (s-s'), feet	Depth to water Dw, feet	Dw, feet				
11:45	-	0		7.07	0					7.36	6.07		Static water level
11:49	-	1600											PUMP ON
12:03	-	1100											Decreased Q
13:25	-	1100		52.41	45.34					9.67			
13:30:20	0	1600											Start maximum Q
13:38	8	1586		90.51	83.44					10.37			
13:50	20	1588									6.32		
13:59	29	1583		91.58	84.51					10.49			
14:31	61	1577		92.03	84.96					10.56			
14:43	73	1570									6.39		
15:10	100	1569		92.24	85.17					10.56			
15:26	116	1570		92.43	85.36					10.61			
15:34	124	1570									6.43		
15:45:00	135	0	0										PUMP OFF
	135.5		0.5										START RECOVERY
	136		1										
	137		2										
	138		3										
	139		4										
	140	5	1.447	8.26		1.19	84.24						
	141	6	1.371	8.17		1.1	84.33						
	142	7	1.307	8.13		1.06	84.37						
	143	8	1.252	8.04		0.97	84.46						
	144	9	1.204	7.96		0.89	84.54						
	145	10	1.161	7.97		0.9	84.53						
	147	12	1.088	7.88		0.81	84.62						
	150	15	1	7.64?		.57?							
	155	20	0.889	7.72		0.65	84.78						
	160	25	0.806	7.62		0.55	84.88						
	165	30	0.74	7.57		0.5	84.93						
16:23	173										6.33		
16:26:00	176		41	0.633	7.47		0.4	85.03					
Jan.3, 2006											6.10	8:34 AM	
Jan.5, 2006											6.54	2:25 PM	

Plot of $\log_{10}(t/t')$ vs. residual drawdown s' gives a transmissivity (T) of 123,000 ft²/day

APPENDIX V
GEOPHYSICAL LOGS



Dec. 22, 2005 Thurs

Averaging = 4

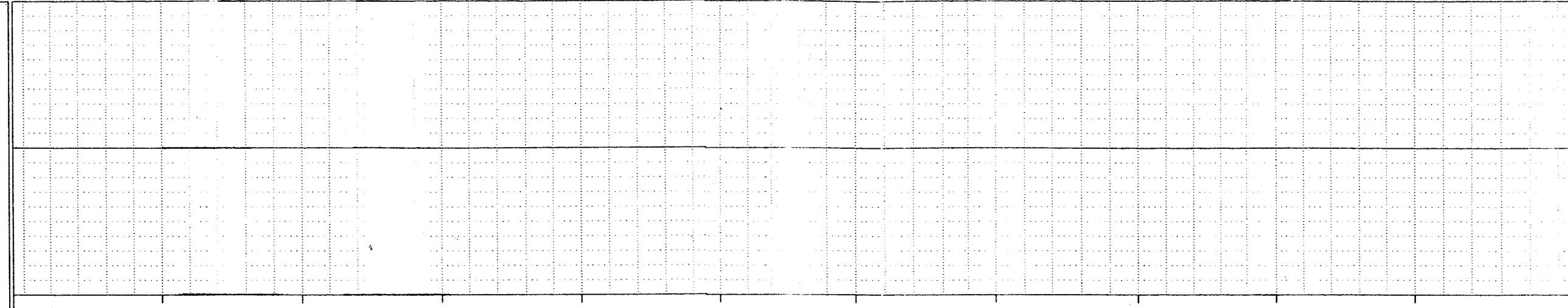
TH-1-INWR GAMMA UP

NGamma
CPS

154

18

10 20 30 40 50 60 70 80 90 100

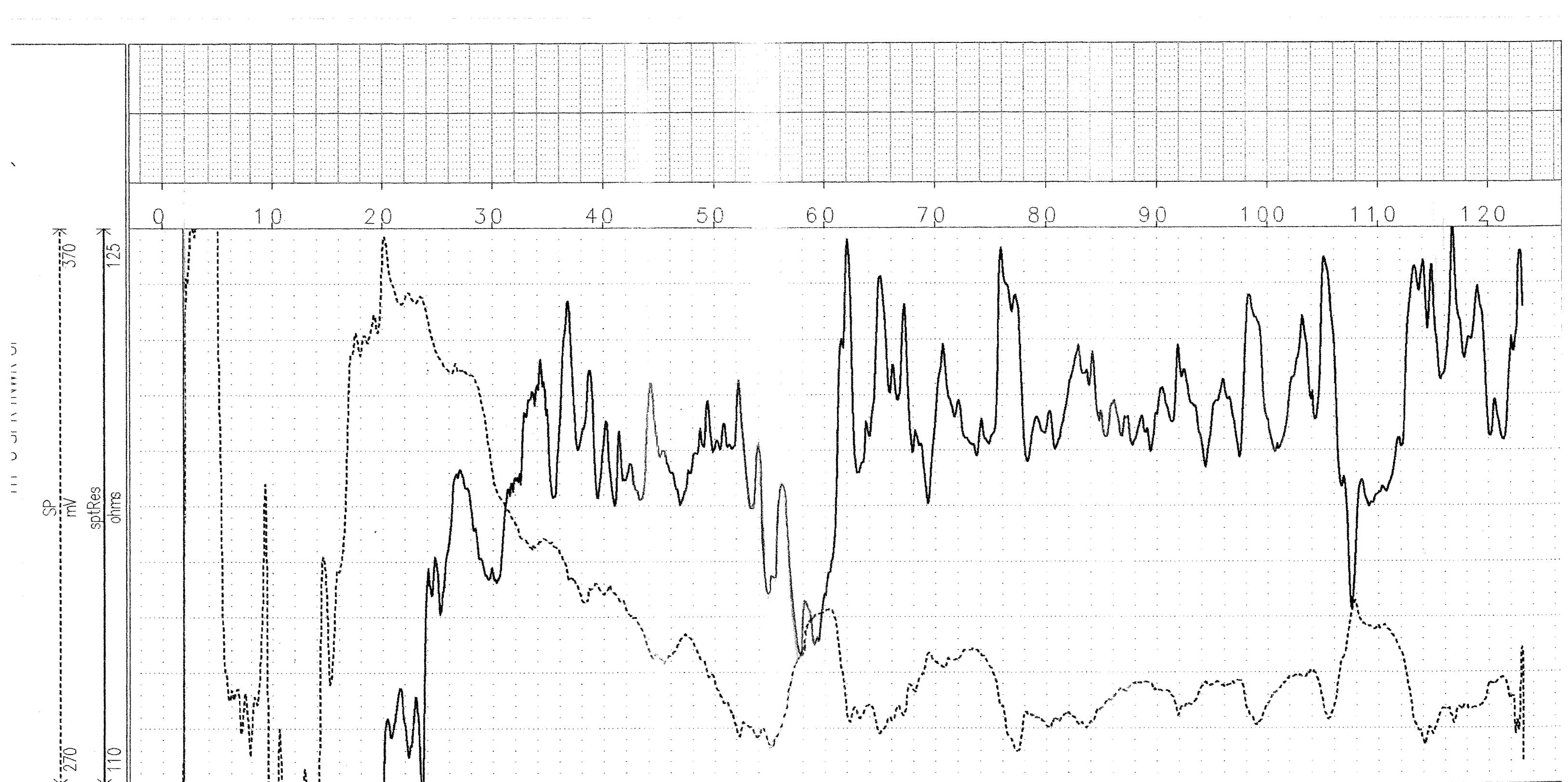


TH-1-INWR GAMMA UP

NGamma
CPS

154

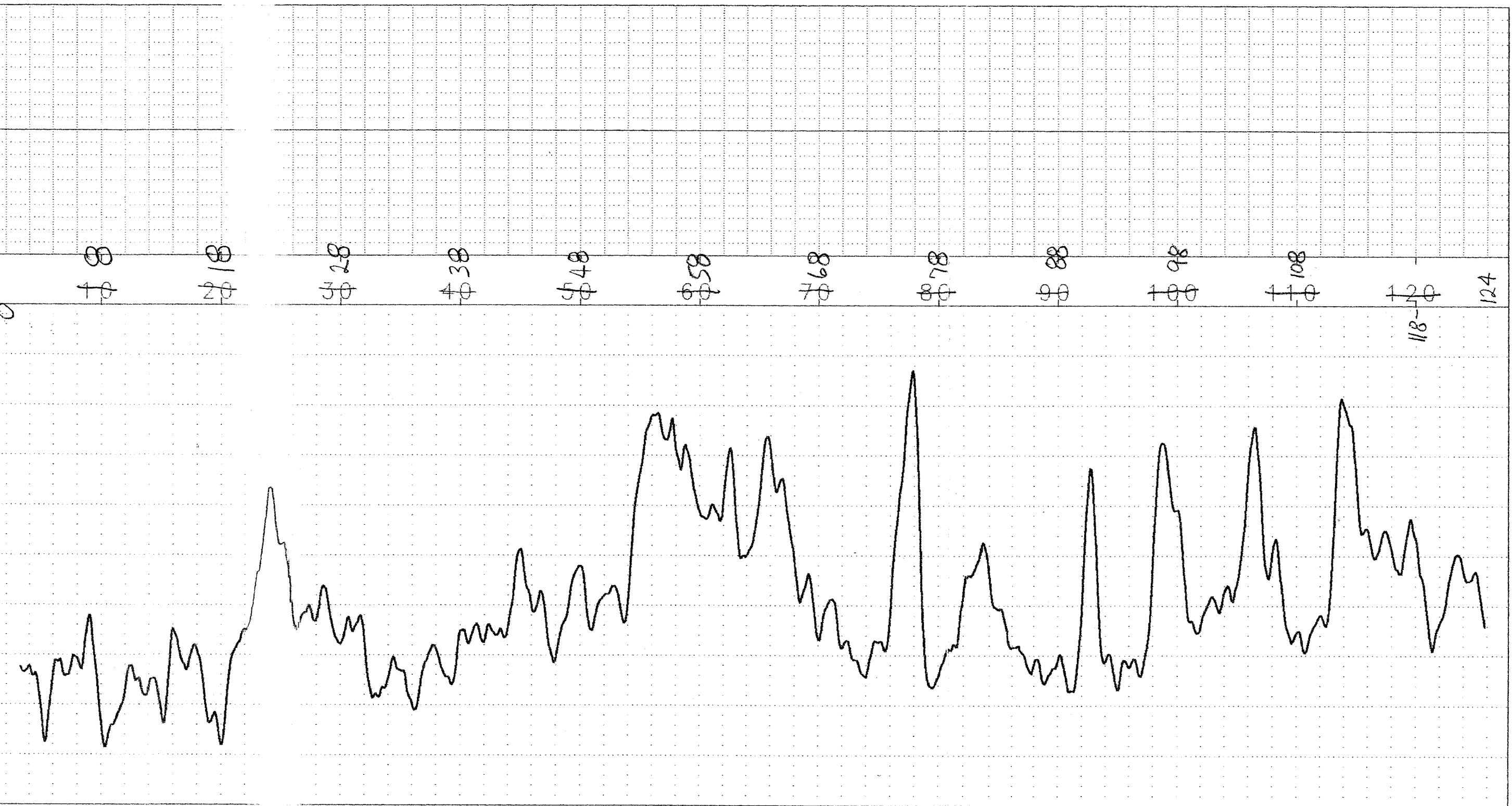
18



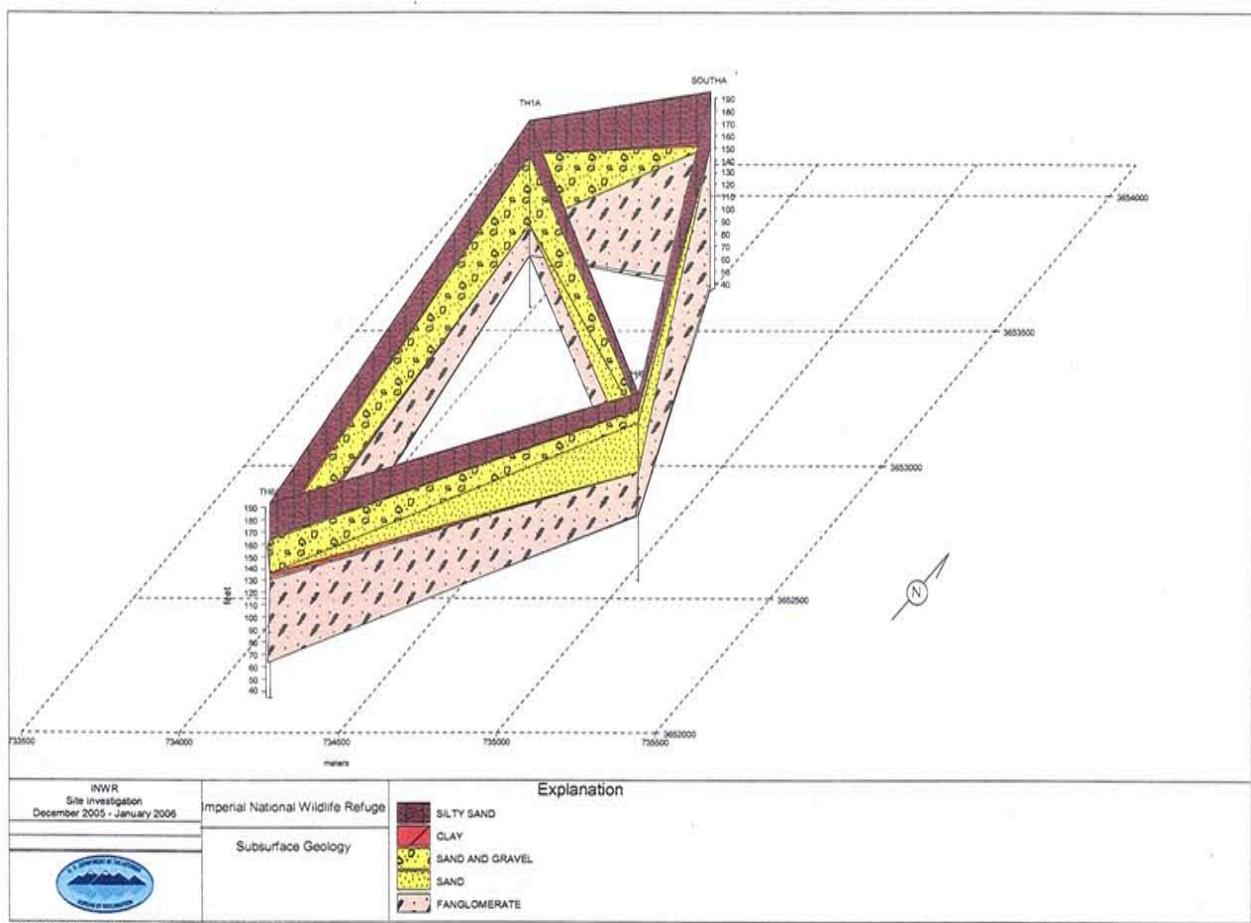
TH-6 INWR GAMMA DOWN

$\text{Filter} = 3$, Averaging = Yes

$$F_{\text{filter}} = 3, \text{ Averaging} = \text{Yes}$$



APPENDIX VI
FENCE DIAGRAM



The above fence diagram depicts a 3-dimensional, north-trending aspect of the subsurface geology. The four deep holes used for this interpretation are TH-1, TH-6, TH-4 and INWR Well #1. The left (west) side of the diagram is bordered by the Colorado River and the right (east) side would essentially be bordered by the Martinez Lake Inlet Channel.

The recommended sites for additional production wells would be along the north edge of the diagram. We interpret the fanglomerate as a pre-Colorado River deposit that thickens and approaches the surface in an eastward direction. The silty-sand layer remains fairly consistent and underlies the entire project area. There is very little clay and most clay beds appear to be near the base of the Colorado River sediment at the fanglomerate contact.